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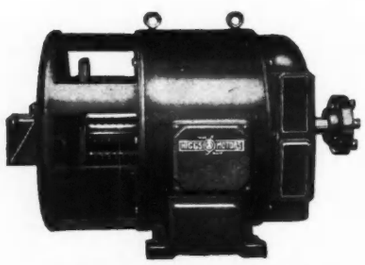

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COLLOIDAL GRAPHITE IN ASSEMBLY LUBRICATION.

By E. A. SMITH.

WHILE considerable thought has been devoted to the metallurgy and design of stressed moving parts of mechanical equipment, it is doubtful whether the lubrication of those parts on assembly has received the attention that it deserves. After finish-machining, the main consideration has been running-in, which leaves an important gap in the progress of a machine from the shop to the user; for assembly lubrication is by no means merely a matter of smearing oil on to the working faces before they are brought together.

It is evident that, when two newly-machined faces are run together for the first time, boundary conditions of lubrication will prevail. Such lubrication means high friction, excessive wear and the possibility of scoring, as the comparative roughness of the faces makes it difficult to separate them effectively with a fully-fluid oil film. Contour records* of some typical finishes are shown in Fig. 1, herewith, the magnification being approximately 2,000 in the vertical; *a* and *c* are fine-bored finishes and *b* is a turned journal finish. It is clear that high spots of this nature will pierce the strongest oil film when the faces commence to rub over each other. Localised deformation and melting of the asperities will occur, and the problem is how to prevent them from making metal to metal contact during the initial movement of one face over the other.

Fig. 1.

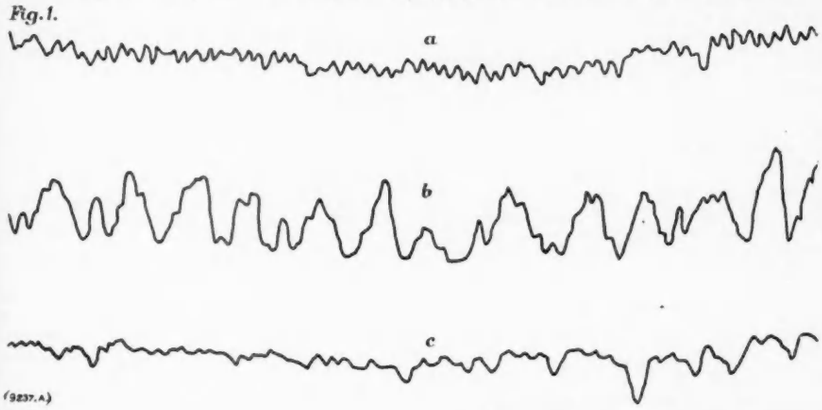


Fig. 2.

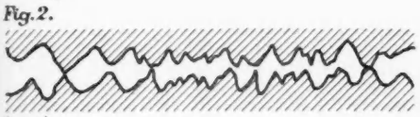
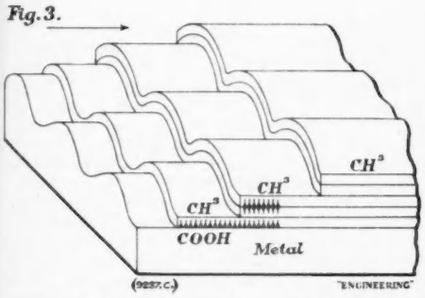


Fig. 3.



When two working faces are assembled, the condition can be represented pictorially as in Fig. 2, from which it is apparent that they are in contact before rubbing commences, and are ready to grind each other. The application of oil provides no adequate remedy, and the position can be summarised as follows: (1) metallic abrasion takes place; (2) bearing temperatures are high; (3) the oil film cannot provide effective lubrication alone; (4) the metallurgical condition of the faces is disturbed; (5) formation of a Beilby layer is discouraged. Protective lubrication during assembly should provide the advantages that scoring and seizure are absent, running is cooler, wear is controlled and a Beilby layer is formed, bedding-in being, thereby, more accurate.

For an oil film to form on a rubbing face, the oil must "wedge" itself in between the faces. This is a hydrodynamic effect and is of considerable importance at the commencement of rubbing of two newly-machined faces. Such wedging action is exhibited more strongly by some lubricants than others, and research work, using electron diffraction, has indicated that oils which adsorb to a face readily also show more pronounced wedging. Long-chain polar compounds, such as fatty oil, give the best wedging action, while non-polar hydrocarbons, such as paraffinic oil, exhibit the effect to a small degree, which disappears when the temperature rises slightly. In both instances, of course, a film so created would be unable to withstand the piercing action of high spots, while "straight" mineral oil is of little value as an assembly lubricant.

FIG. 4.

A newly-machined face discourages not only wedging but the orientation of the molecules of an oil necessary to their anchoring to the face. In their book, *The Chemical Background of Engine Testing*, R. E. Burk and O. Grummett say that "The interlocking asperities of such surfaces and the extreme pressure and temperature conditions thus produced upon sliding makes the action of an adsorbed layer impossible . . . and would make the induction of the wedging effect less probable." In effect, therefore, newly assembled working faces of equipment both prevent the formation of a full oil film, and, where the latter has succeeded in forming, tend to destroy it, which means that ordinary lubricants are of little use for protecting new faces.

The rate at which an oil spreads over a face in contact with another depends to a certain extent on the wedge effect, but other factors enter into the question, and, for that reason, oil-spread should be considered separately. Speed of spreading is necessary for safety in lubrication, for, where the oil film is broken, it must re-form as rapidly as possible. This characteristic is sometimes referred to as "wetting" a surface, and depends on the type of metal, the type of finish, and the kind of lubricant. Chromium, for example, is notoriously bad for oil spread, particularly when highly finished, and, consequently, is difficult to lubricate initially. Stainless steels suffer from a similar drawback, but the commoner metals used for friction faces of mechanical equipment, such as cast iron, Babbitts, and non-ferrous alloys of the copper-lead type, permit a reasonable degree of spread.

The mechanism of oil spread is tied up with adsorption, a phenomenon in which the molecules of certain oils anchor themselves to the face on which they lie. Thus an animal oil, or one of vegetable origin, will generally show good oil-spread compared with, say, paraffinic oil. The manner in which the former type forms a film on a surface is shown pictorially in Fig. 3, herewith, the COOH end of the molecule constituting, as it were, the anchor for the initial layer, over which subsequent layers can slide more readily. If the surface is provided with such a layer, therefore, better oil-spread is achieved. Cast iron is easily wetted by oil because of its content of graphite, which, when the surface is rubbed, comes out and is spread over the surface by the rubbing,

The type of finish influences the metallographic changes that take place in a rubbing face when it is first put into operation. In the first place, the degree of finish will exert a profound effect; that is to say, whether it is rough grinding, fine grinding, honing, buffing or micromatic finish. Such finish will determine the initial friction and wear of the rubbing face in general, but a more subtle effect is that of the direction of finish marks. Parallel finish marks are inimical to wear resistance and effective lubrication, while those at right angles, or which cross each other, offer the best conditions for oil-film formation and reduced wear. Where the finish marks are parallel to the direction of rubbing, a high rate of initial and subsequent wear is encountered. The detritus taken from the surface during rubbing is swept along the furrows and lost. If the marks are normal to the direction of rubbing, there is a greater tendency for metal to flow into the furrows, to build up a denser and more wear-resistant surface. Fig. 4, on this page, shows the survival of a finish mark on a mild-steel face being run-in, and how it is undergoing plastic deformation rather than abrasion.

The influence of the direction of finish marks with respect to rubbing for different lubricants is illustrated in Fig. 5, on page 506; it is evident that, given fully protective lubrication, as with colloidal graphite in the oil (curves *c* and *d*), such an influence can be largely suppressed. J. J. Trillat has commented on the way that finish influences oil-spread, marks which cross each other's paths promoting wetting. The difficulty presented by ensuring such an optimum finish in practice can be surmounted, however, on the lines indicated below.

When boundary conditions of lubrication prevail, surface temperatures of up to 600 deg. C. may be anticipated on new faces. In general, the limiting temperature is that of the metal with the lower melting point, if dissimilar bearing metals are rubbing together. Dr. F. P. Bowden and Dr. E. Ridler* give the following values for constantan rubbing on steel, at 100 cm. per second, for a measured coefficient of friction of 0·23; where the whole of the surface areas are in rubbing contact, the calculated surface temperature is 75 deg. C.; with one-tenth of the surface in contact, the calculated temperature is 414 deg. C.; and with one-hundredth in contact, 2,373 deg. C.

These figures are quoted to illustrate how temperature plays a part in the lubrication of a new face, to modify the immediate surface structure of the metal. Melting temperatures are involved, which might bring about plastic flow; and, if such values are limited to the immediate surface of a friction face, it should be remembered also that wear and lubrication are themselves surface phenomena. Adsorption of an oil film is a mechanism extending to only a few molecules from the metal surface, and therefore it might be expected that such adsorption would be profoundly modified, if not prevented wholly, by temperatures of the order of that quoted. Fluid-film conditions of lubrication are clearly unobtainable in newly-machined faces when initial rubbing takes place after assembly. Temperatures and loads may not only induce boundary-film conditions, but would tend to give

* H. Shaw, *Proc. I.P.E.*, vol. 15, No. 8 (1936).

* *Proc. Roy. Soc. A*, vol. 154 (1936).

metal-to-metal contact. For that reason, a solid lubricant is desirable, either of an extreme-pressure or a mild extreme-pressure type.

The value of colloidal graphite for this purpose lies in the characteristic features that an oil-wedge effect is promoted and oil-spread improved on all surfaces, protection is given against metal pick-up, running-in wear is controlled, higher loads can be sustained, and there is a lower initial friction, both static and kinetic. The practice of using colloidal graphite during assembly is fairly widespread among manufacturers of mechanical equipment, but there appears to be a lack of understanding of the fundamental reasons for this practice.

It is an anomaly that colloidal graphite both promotes the oil-wedge effect and, at the same time, renders it unnecessary. In encouraging molecular orientation and adsorption of oil molecules, as shown in the X-ray studies of J. J. Trillat and H. Fritz,* a graphited surface formed with colloidal graphite on steel assists the oil wedge effect. H. R. Wolf has also drawn attention to the increased secretion of oil in a graphited metal face, an effect arising from better adsorption.

Because the flat colloidal particles of graphite lie between high spots on a newly-machined face, they provide the protection needed against metal pick-up during the initial rubbing of the faces over one another. Fig. 6, on this page, illustrates this, showing the particles, greatly magnified, lying on the friction faces of two parts brought together for running-in. It will be observed that they provide the much-needed slip planes between high spots. When the latter come together during rubbing, shear takes place in the graphite, as has been indicated by N. K. Adam†. The particles being so easily sheared within themselves, the overall effect is one of lubrication, friction being kept low in consequence, and so minimising the necessity for high oil-wedge activity.

The effect of a graphited surface on oil-spread has been commented on by several observers. The improvement that it affords arises from the fact that the flat microscopic particles have high free-surface energy, particularly when they are sheared, and attract the molecules of oil, anchoring them to the bearing face. As soon as the molecules are anchored in this way, further layers of molecules slide over the initial one, giving rise to oil-spread.

From many tests carried out to demonstrate this improvement, the comparison in Table I is selected

TABLE I. *Spread of Oil Over Surfaces.*

Time, min.	Area of Surface Covered.		
	Untreated Chromium.	Buffed with Colloidal Graphite.	Film Formed with Colloidal Graphite.
1	0·63	2·54	1·76
5	0·78	4·90	3·14
10	—	7·06	—
15	0·95	—	4·52

as showing the relative increase in spreading of oil over a polished chromium surface and over the same kind of surface on which a thin film of graphite has been formed with colloidal graphite. The film on the face which was buffed in the presence of colloidal graphite was too thin to observe with the naked eye. This table shows that oil spread was increased threefold to eightfold by suitable treatment, making it no longer necessary to consider the type of metal used in a working face. It should be emphasised that, in forming a graphoid surface or a graphited film on a metallic face, not only is the oil affinity of the face intensified, but it is given lubricating characteristics, whether oil is present or not.

The formation of a graphoid surface or a thin graphite film on a working face before assembly ensures protection against metal pick-up, a property of colloidal graphite in lubrication which is so well known as hardly to need comment. Numerous practical tests, in several countries, have confirmed the earlier experiments‡ undertaken at the National Physical Laboratory, when a journal bearing ran for several hours, without difficulty, after the oil supply had been cut off, the bearing having been previously lubricated with graphited oil. The results obtained by Shaw* were equally graphic in illustrating the protective action of this form of lubrication; these are shown in Fig. 7. Three tests were carried out with plain oils, A, B and C, the supply being cut at the points 1, 2 and 3, respectively, after running for five hours. After the graphited oil was cut off, the bearing continued to run for 181½ hours. In providing such safeguards against seizure, newly-machined faces are most protected just when they need the maximum protection. It is during the initial revolutions after assembly that damage is usually caused to a bearing face, and the

Fig. 5.

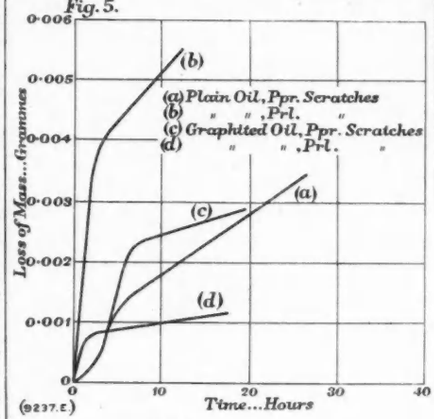


Fig. 6.

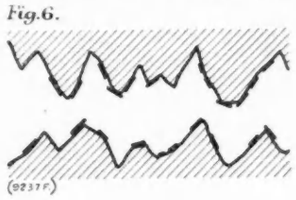
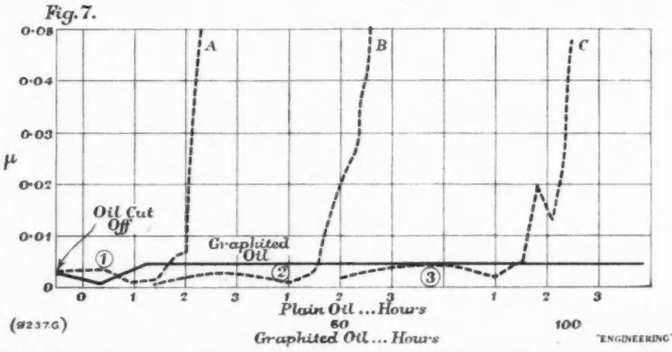


Fig. 7.



value of colloidal graphite in preventing such damage is then seen at its best.

While considerable care is often devoted to the mechanical process of assembly, to ensure that opposite faces bed together, much of this care can be nullified by allowing the faces to wear rapidly during running-in. The object should be to allow them to undergo gradual metallurgical and dimensional adjustment, and this can only be ensured by correct lubrication. Controlling the rate of wear means not only more accurate bedding-in, but the formation of better wearing surfaces. Denser surfaces are produced and, in general, the whole process, when carried out correctly, can best be described as "conditioning." In certain cases, particles of colloidal graphite, when present at the commencement of rubbing of newly-machined faces, may become incorporated into the surface layers of metal, to provide a low-friction metallic "skin."

Possessing, as it does, mild extreme-pressure properties, colloidal graphite is clearly indicated for new faces during initial rubbing. While the high spots can pierce the oil film without difficulty, they cannot displace the adsorbed slippery particles of graphite, so that, with the latter present, higher initial loads can be sustained without overheating. Tests on a Riehle machine, summarised in Table II, illustrate the load-carrying capacity of colloidal graphite. This higher load-carrying capacity is more evident still at higher temperatures, when a plain oil is thinned out by heat. Experiments at the National Physical Laboratory indicated that, when the load on a bearing was taken to over 1,000 lb. per square inch, and the temperature to 80 deg. C., the superiority of a graphited oil was pronounced.

The importance of keeping friction at a minimum in newly-assembled faces cannot be over emphasised. It is upon the success of this measure that the benefit of assembly lubrication rests. There are two distinct phases in friction to be considered,

TABLE II.—*Comparison of Oils.*

——	Medium Viscosity Oil	Same Oil, plus Colloidal Graphite
Load, lb per sq in.	100	100
Rubbing speed, ft. per min.	196	196
Torque, lb. ..	19	16
Load	Above 100 lb. per sq. in. resulted in seizure	180 lb. per sq. in.
Torque	—	19 lb.

static and kinetic. The former might be described as the frictional force requiring to be overcome to start two faces sliding over each other from a stationary condition. It is, in effect, starting friction, and, leaving aside the inertia of a moving part, is a measure of the starting torque, or energy input, required to start movement. When the two surfaces have begun to rub together, the static friction gives way to kinetic, or sliding, friction. The former is of a much greater magnitude than the latter. Values obtained by Fogg and Hunwicks* convey an idea of the static friction with dry surfaces and those lubricated with various liquids. It is to be observed that the surface produced on steel with colloidal graphite in oil is among the best, and compares with that obtained with fatty oil. The maximum coefficient obtained with steel on steel was 0·58; benzene on steel reduced the value to 0·48; glycerine, to 0·20; mineral oil, to 0·15; and graphited oil, to 0·12. The minimum coefficient obtained was 0·08, with oleic acid.

In considering new rubbing faces one should relate static friction to the kinetic value. Both are a measure of the overheating and wear to be anticipated. The rubbing friction for surface films formed on steel with different dispersions of colloidal graphite, and that of an oil film, under boundary conditions, of a good quality aero-engine lubricant, compare as follows: a dry film formed with Aquadag colloidal graphite in water gave a kinetic friction coefficient of 0·06. A dry film of colloidal graphite in white spirit gave a coefficient of 0·04; with colloidal graphite in alcohol, 0·05; and an oil film alone, 0·06.

There are three methods by which colloidal graphite can be used in assembly lubrication: it may be burnished or buffed on to the newly-machined faces, painted or sprayed on to leave a graphite film, or

* *Jl. Chim. Phys.*, April, 1938.

† *The Physics and Chemistry of Surfaces.* Oxford University Press (1941).

‡ H. Higinbotham, *Jl. I.A.E.*, January, 1935.

* H. Shaw, *The Machinist*, March 19, 1938.

* A. Fogg and S. A. Hunwicks, *Jl. Inst. P.*, vol. 26, No. 195 (1940).

applied in oil. As it forms an effective dispersion in mineral oil and also in volatile carriers, such as white spirit and acetone, it can be employed in various ways to suit production. Finishing operations on the working faces of mechanical equipment can be conveniently carried out in the presence of colloidal graphite, so that the particles of the latter are worked on to the faces. Thus, honing can be carried out with either colloidal graphite in oil or in white spirit, the dispersions being added to the coolant. A small percentage only of these dispersions is required, the quantity depending on the nature of the finishing operation. The same technique can be used for buffing or burnishing, using for example, a dilute dispersion in paraffin or white spirit.

The range of such volatile dispersions available makes it possible to form a dry slippery film on almost all types of surfaces. The best results are obtained by first degreasing the parts to be treated, and then painting or spraying on a dilute dispersion of colloidal graphite in water, alcohol or other suitable liquid, which will evaporate to leave a dry adherent film. Where it is not possible to degrease the parts beforehand, the film can be formed with colloidal graphite in white spirit, but it is preferable for the part to be warm, or even hot, before the application. This assists the evaporation of the liquid, and helps to bind the film to the face. It is not always necessary to have an adherent film to produce good results, however; as long as the particles of colloidal graphite are present when the parts are assembled, the desired protection will be afforded. A dry film can be formed rapidly on non-greasy surfaces with colloidal graphite in alcohol, the volatile carrier evaporating speedily at room temperatures. Whichever dispersion is used, the resulting graphite film can be polished, if desired, with a dry mop, the appearance of the part being clean and bright.

The film can be applied by painting on the appropriate diluted dispersion, using a clean soft brush, or spraying can be adopted, using a gravity-fed gun for preference. A third method is to dip the part into a bath holding a diluted dispersion of colloidal graphite; if the part is warm, it dries quickly after emerging from the dip. The appropriate temperatures vary according to the nature of the dispersion used.

Some manufacturers apply a concentrated dispersion of colloidal graphite in oil directly to the working faces of equipment before assembly and this has been found both convenient and effective. No prior degreasing or treatment is required, the mixture being swabbed or painted on to the faces liberally. The equipment is then assembled in the usual way. This method ensures the presence of a liberal supply of colloidal graphite during the initial movement of the working faces. In general, however, a diluted dispersion is employed.

LITERATURE.

Flow Through Standard Nozzles, Orifice Plates and Venturi Tubes. By J. R. FINNIECOME, M.Eng., M.I.C.E., M.I.Mech.E. "Mechanical World" Monograph No. 39. Emmott and Company, Limited, 31, King-street West, Manchester 3, and 21, Bedford-street, Strand, London, W.C.2. [Price 3*s.* net.]

THE measurement of fluid flow in terms of the differential pressure across an artificial constriction in a pipe of circular cross-section was the subject, during the years between the wars, of several elaborate experimental investigations, primarily aimed at standardising designs of equipment for industrial use and establishing numerical coefficients appropriate to a wide range of service conditions. The detailed results of these researches, published in different languages, and the standards set up, especially in Germany and the United States, are obviously of great interest to civil and mechanical engineers, and Mr. Finniecome has made an intensive study of the whole subject in order to present concisely a comprehensive survey of the physical aspects of flow measurement for air, steam, gases and water, by means of nozzles, diaphragm orifices and Venturi meters. Starting with the fundamental formulæ based on the hydrodynamic and thermodynamic theories, he derives general expressions for flow through the three types of meter and qualifies them by empirical discharge coefficients, values of the latter, according to different authorities, being instructively compared. The effects of adiabatic index on the pressure/discharge relationships for air and steam are next introduced, in which connection the author's graphical presentations of kinematic viscosities are likely to prove especially helpful to engineers who use such data only occasionally. The author's concern being primarily with standardised metering, he pays a good deal of attention to the critical Reynolds numbers above which flow factors remain sensibly constant, though he says nothing of the characteristic behaviour of flowmeters at very low Reynolds numbers.

The highly condensed style makes this book essentially one for technicians who are already well-versed in the theory and practice of fluid-flow measurement and are mainly interested in comparing the latest and most advanced data and performance formulæ for the three commonest types of differential-pressure meters. Newcomers to the subject will find the mathematical and graphical matter, which forms the greater part of the book, somewhat unnecessarily difficult to follow, not least because of a large number of typographical errors, many of which are not apparent without laborious checking of equations and scrutiny of tables and graphs. For the careful reader, however, these defects will not detract seriously from his appreciation of Mr. Finniecome's attempt to analyse a great volume of important research and to reduce the results to a common basis.

The Efficient Use of Steam. By OLIVER LYLE. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 15*s.* net.]

IT would be a great pity if the disappointment of those who purchased the volume on *The Efficient Use of Fuel*, on the strength either of its title or of its sponsorship by the Ministry of Fuel and Power, should deter them or others from acquiring its companion volume on *The Efficient Use of Steam*; the new work is in a different category. Indeed, it is not too much to say that the present book is in a class by itself, for we can think of no other that deals in anything like so thorough and comprehensive a manner with the efficient employment of steam after it has left the boiler stop-valve. It is, moreover, eminently readable, being written for practical engineers in their own every-day language by an author with a wide experience and a profound interest in the operation of steam machinery and appliances. The substance of about a third of its 900 pages has appeared previously in various bulletins of the Fuel Efficiency Committee of the Ministry, but even the comparatively few people who can put their hands on these will be glad to have the same information presented in logical order and permanent form, as part of a complete treatise on the management of steam.

The first three of the 26 chapters deal with the properties of steam. The author has succeeded in presenting the principles of the subject to the ordinary steam user in a vivid and practical manner, and though, when necessary, he makes full use of such devices as the entropy diagram and Gibbs's Function, there is nothing that the most unmathematical reader need be afraid of. All calculations are confined to simple arithmetic, nor is anything that could be dignified by the name of mathematics to be found elsewhere in the text, which covers about every imaginable application of steam to power, heating and process work in factories. The emphasis is on using the heat of the steam in the most advantageous manner—not merely avoiding the more obvious sources of loss, but planning and controlling the system of operation so that every pound of steam delivered into the factory shall be made to give its utmost return in the form of finished products. As Mr. Lyle points out in his introduction, immense pains are often taken to get an extra two or three per cent. efficiency in the boiler-house, while all the time the factory may be consuming two or three times as much steam as is really necessary for the work done. It is this sort of thing that he sets himself to counter. He reviews, one after another, the practical questions that arise in the employment of steam for particular purposes, and in the operation of the plant involved. Piping, lagging, trapping, metering, the combined use of heat and power, automatic controls, multiple-effect evaporation, heat storage and many other subjects are given individual attention.

These matters lead up to what is much the longest chapter in the book—one dealing with the establishment of heat balances for factories. Mr. Lyle asserts that nine factories out of ten could bring down their overall steam consumptions by 25 per cent. within a reasonable time if only they would take the trouble to find where the heat goes to. In support of this belief, he gives figures relating to his own great sugar refinery, showing that, as a result of such investigations, it had been possible progressively to reduce the amount of coal consumed per ton of sugar from 0·25 ton in 1937 to only 0·134 ton in 1940, thereby effecting a saving of no less than 48,250 tons of coal a year, or 46 per cent. of the former consumption for the same duty. He believes that most factories could be made to show a comparable improvement if the managements really gave their minds to it. The plan involves making a careful estimate of what may be regarded as reasonable perfection, and continually striving to attain or beat it. The author discusses in detail the processes of a laundry which was using 22 tons of coal a week, whereas about 9 tons would have been an attainable figure, inclusive of drying, space-heating and everything else. The thermally more complicated processes of a brewery and of a food-extract factory are considered in equally full detail, to illustrate what great savings are possible, and how they might be obtained, even in apparently well-managed plants.

It is a pleasure to commend the volume to all concerned with the use of steam in factories, and to students as an admirable exposition of practical thermodynamics with regard to steam. It is illustrated with over 400 engravings, mostly of a diagrammatic nature, and terminates with a large collection of appropriate tables and an unusually good index. The author has a pleasing style; and, if some of his colloquialisms might tend to make a pedant flinch, such critics should be disarmed by the wittily appropriate quotations from authors ranging from Homer and Tacitus to Milton and Shakespeare, with which the various chapters are headed.

The Railways of Britain, Past and Present. By O. S. NOCK, B.Sc. (Eng.), A.M.I.C.E. B. T. Batsford. Limited, 15, North Audley-street, London, W.1. [Price 15*s.* net.]

MR. NOCK has served a long and observant apprenticeship to the difficult art of writing about railways in a manner that shall appeal at once to the uninitiated user of rail transport and to the reader who is technically well informed; and the fruits of that experience are well displayed in his latest book. While, in general, it belongs to that category of railway literature which may be said to have originated with F. S. Williams's *Our Iron Roads*, it is much more of a connected history than that mid-Victorian classic, and is more liberally garnished with the facts, technical and historical, that the modern student of railway literature expects and has learned to appreciate. In this respect, perhaps, its value may come to be recognised more fully in a few years' time, when the process of unifying the nationalised railways has progressed farther and the now-familiar points of difference between the main systems begin to disappear. Meanwhile, it may be commended to all who are interested in railways as a well-balanced survey of a field in which British engineers have been particularly distinguished.

STANDARDISATION OF ELECTRICAL CABLES AND WIRES FOR GOVERNMENT SERVICES.—The Committee on the Standardisation of Electrical Cables and Wires for Government Services, Ministry of Supply, "Walsingham," Manor Park, Chislehurst, Kent, have recently issued a specification (No. 23) dealing with the radio-frequency cables used by the fighting services and other Government departments. Copies of the specification are obtainable from H.M. Stationery Office at the price of 1*s.* 3*d.* net.

SIMULATION OF HIGH AIR TEMPERATURES BY HYDROGEN ADMIXTURES.

By BORIS N. COLE, Ph.D., B.Sc., Wh.Sc.

WHILE participating in research, recently carried out at the University of Birmingham, on problems related to exhaust-pulse scavenging, the author was faced with the need to conduct certain air-discharge experiments at atmospheric temperature rather than that of a prototype engine. As in many other kinds of gas-flow research, this procedure was dictated partly by the difficulty of installing suitable temperature-control apparatus, and partly by the potentially damaging action of high-temperature air upon special pressure-indicating equipment. However, since pressure-wave phenomena and sonic gas velocities were essentially involved, results derived from low-temperature experiments were not wholly applicable to prototype conditions of high air temperature, and it became necessary to find some artifice for simulating these latter conditions. This was achieved by using, at the convenient atmospheric temperature, mixtures of hydrogen and air, or more safely, hydrogen and nitrogen, adjusted so as to reproduce the prototype high-temperature properties of pressure, density, elasticity and acoustic velocity. With air or nitrogen as the basic fluid, hydrogen forms the best choice for an admixture, since it is a powerful density-reducing agent, and furthermore possesses a ratio of specific heats substantially equal to that of either base.

Since this technique may apply to a wide range of experiments involving the adiabatic compression or expansion of an initially static air charge, it is proposed to discuss three special cases which should meet all possible requirements: (1) simulation of prototype temperature within the experimental charge; (2) simulation of an adiabatic temperature relationship with respect to initially static gas in the downstream region (a requirement that may arise in sudden discharge as distinct from normal steady flow); and (3) a combination of both preceding cases. Consideration of each case will be prefaced by specimen requirements drawn from the author's own experience, but the reader may easily envisage similar requirements occurring in the field of, say, compressor or gas-turbine research.

Considering first the simulation of temperature. When investigating sudden discharge from an engine cylinder directly to atmosphere, the ambient temperature (viz., atmospheric) is obviously the same for both prototype and experimental conditions. It therefore only remains to simulate the prototype cylinder temperature prior to release. Let the absolute pressure, absolute temperature, density, acoustic velocity, and gas constant relating to prototype air conditions be denoted by P_0, T_0, ρ_0, a_0 and R_0, respectively, and let the ratio of specific heats, common to all the gases considered, be denoted by γ. If the constituent gases, hydrogen and air (or nitrogen), of the experimental mixture be indicated by suffixes 1 and 2, respectively, then the partial pressures P_1 and P_2, and the corresponding densities ρ_1 and ρ_2 must be adjusted to reproduce prototype conditions while remaining at atmospheric temperature T_a.

From the laws for gaseous mixtures

$$P_1 + P_2 = P_0 \quad . \quad . \quad . \quad (1)$$

and

$$\rho_1 + \rho_2 = \rho_0 \quad . \quad . \quad . \quad (2)$$

The prototype acoustic velocity, which is to be reproduced experimentally, is given by

$$a_0^2 = \frac{\gamma P_0}{\rho_0} = \gamma R_0 T_0,$$

whence, on substituting for P_0 and ρ_0 from (1) and (2),

$$\frac{P_1 + P_2}{\rho_1 + \rho_2} = R_0 T_0, \quad . \quad . \quad (3)$$

From the general gas law, $\rho_1 = \frac{P_1}{R_1} T_a$ and $\rho_2 = \frac{P_2}{R_2} T_a$. Upon substituting these relations in (3), putting $P_1 = P_0 - P_2$, and simplifying, it is readily established that

$$\left(\frac{P_2}{P_0}\right) = \left[\frac{\frac{R_2}{R_0}\left(\frac{T_a}{T_0}\right) - \frac{R_2}{R_1}}{1 - \frac{R_2}{R_1}}\right], \quad . \quad (4)$$

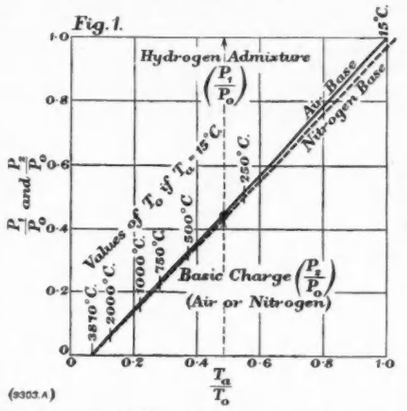
from which $\frac{P_1}{P_0}$ may, in turn, be found.

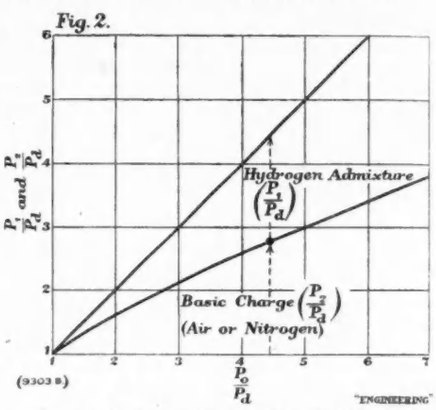
For air, $R_0 = 96$ on the Centigrade scale, and for hydrogen, $R_1 = 1{,}381$. According as R_2 be taken for air or for nitrogen, its value will be 96 or 93, respectively. Inserting these values in (4), the pressure P_2 of the basic charge, to which the hydrogen charge is to be added, is given by

$$\text{(air base)} \quad \frac{P_2}{P_0} = 1{\cdot}0747\left(\frac{T_a}{T_0}\right) - 0{\cdot}0747 \quad (5)$$

$$\text{(nitrogen base)} \quad \frac{P_2}{P_0} = 1{\cdot}0388\left(\frac{T_a}{T_0}\right) - 0{\cdot}0722. \quad (6)$$

These two simple relationships are illustrated in Fig. 1. It should be noted that the range of application of these lines is limited, since, depending on whether $\frac{T_a}{T_0}$ is very low or very high, the partial pressure of the hydrogen or of the base gas, respectively, may exceed the net pressure P_0, which is an absurd condition. Nevertheless, the range will be found more than adequate for most purposes; for example, with T_a taken as 15 deg. C. (288 deg. C. absolute), the highest temperature which can be simulated is 3,870 deg. C.





Having dealt in the previous case with the simulation of adiabatic temperature relationship, it now remains to simulate the actual prototype temperatures, prior to release, of both cylinder and exhaust-pipe gases. The undiluted downstream base gas of the previous case should now be replaced by a mixture (at pressure P_d and temperature T_a), designed, according to the method for the first case, to reproduce the desired prototype pipe temperature. Upon calculating the corresponding temperature of the prototype cylinder charge, the first case should then be re-applied to determine the correct mixture strength for the experimental charge. Equation (7) should not be used in this latter stage, since it relates to undiluted downstream gases, and not to a mixture.

Mention should be made of two limitations to the artifice as described. Firstly, viscosity has not been taken into account; this point would need consideration before applying the technique to certain scale-model experiments. Secondly, the artifice essentially can apply only to experiments involving adiabatic changes; isothermal changes, or changes in any way affected by external heat exchange, would depend not only upon γ but also upon the gas constant for the mixture, and this, with the strong hydrogen influence, might greatly exceed the value of 96 for undiluted air in prototype conditions.

It may be interesting to add a brief tentative note on low air-temperature simulation, since this is not covered by the method in the form presented above. To reproduce low-temperature conditions, as, for instance, in experiments on refrigeration, the admixture must be heavier than the air base, and, at the same time, possess the requisite value of 1·4 for γ. Although, unfortunately, a single gas of this description is not available, the difficulty may be overcome by employing a synthetic admixture comprising two relatively dense gases selected, respectively, from the monatomic group (for which $\gamma > 1{\cdot}4$) and from the tri- or polyatomic groups (for which $\gamma < 1{\cdot}4$). Adjustment would be made to give a mixture value for γ of 1·4, and it may be shown that this process would be governed by the following equation:—

$$k = \frac{\gamma_a - \gamma}{r(\gamma - \gamma_b)},$$

where $\gamma = 1{\cdot}4$ for the mixture, γ_b and γ_a relate to the constituents, r equals the ratio of their respective specific heats at constant volume, and k equals the ratio of their respective masses or densities. The value of the gas constant for the mixture would be

$$R_1 = \frac{k R_b + R_a}{k + 1}.$$

Once prepared, the synthetic admixture would take the place of hydrogen in the foregoing analysis, the above value of R_1 being inserted in the various equations.

The partial pressure P_2 of the basic charge may thus be found by substituting $\left(\frac{P_d}{P_0}\right)^{\frac{2}{7}}$ for $\frac{T_a}{T_0}$ in (4), it being noted that R_2 may now be substituted for R_0, inasmuch as the present temperature simulation is related to the undiluted base gas in the downstream region, which may or may not be air. Since P_d is usually of atmospheric value, the modified version of equation (4) may be further rearranged to the following convenient form:—

$$\left(\frac{P_2}{P_d}\right) = \left(\frac{P_0}{P_d}\right)^{\frac{5}{7}}\left[\frac{1 - \frac{R_2}{R_1}\left(\frac{P_0}{P_d}\right)^{\frac{2}{7}}}{1 - \frac{R_2}{R_1}}\right]. \quad . \quad (7)$$

This expression is illustrated in Fig. 2, but for the scale employed, the separate lines for the two possible base gases are indistinguishable.

BRITISH INDUSTRIES FAIR, 1949.—Preparations are already being made for next year's British Industries Fair, which is to be held from May 2 to 13, 1949. Particulars may be obtained from the Export Promotion Department, Exhibitions Division, 27, Old Queen-street, London, S.W.1, or to Birmingham Chamber of Commerce, 95, New-street, Birmingham.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR, BIRMINGHAM.

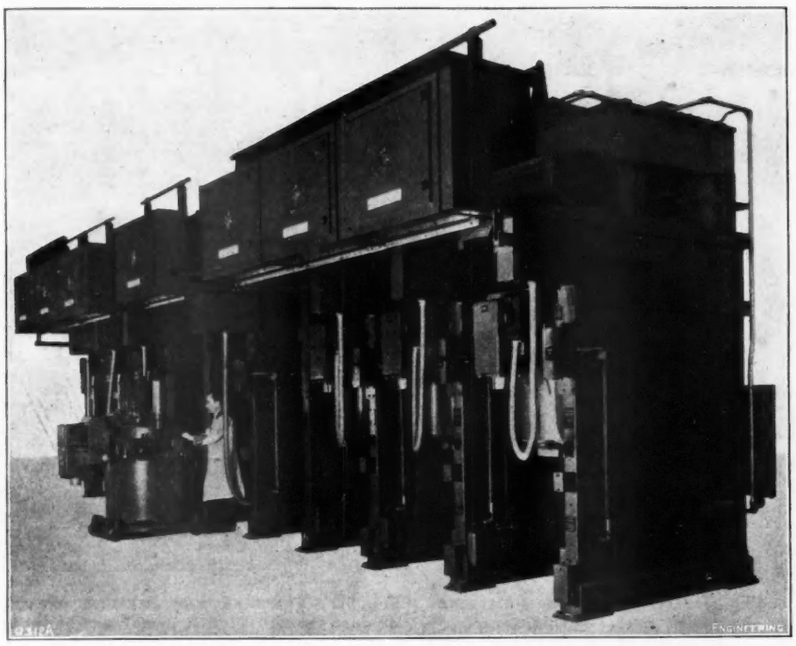


FIG. 34. 33-KV DUPLICATE 'BUS-BAR METALCLAD SWITCHGEAR; MESSRS. FERGUSON, PAILIN LIMITED.

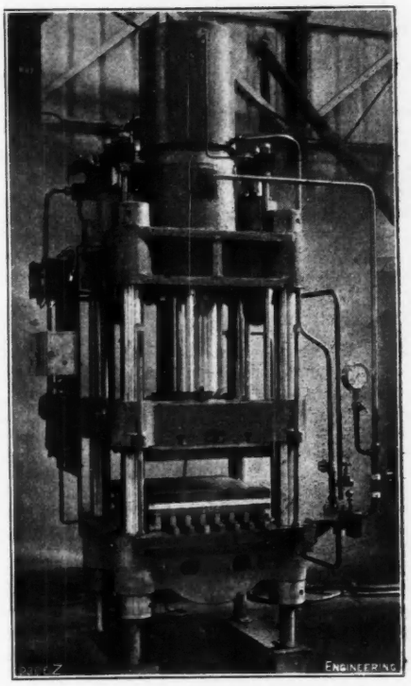


FIG. 35. 150-TON PRESS; MESSRS. T. H. AND J. DANIELS, LIMITED.

THE BRITISH INDUSTRIES FAIR.

(*Concluded from page* 488.)

IN concluding our account of the exhibits at the British Industries Fair, we may refer to the major primary sub-station switchgear manufactured by Messrs. Ferguson, Pailin Limited, Higher Openshaw, Manchester, 11, which was represented at Birmingham by a 33-kV 800-ampere double 'bus-bar metal-clad unit. This unit, which is illustrated in Fig. 34, on this page with one vertically-isolated circuit-breaker withdrawn, is arranged for 'bus-bar selection by the "breaker transfer" method. As will be seen, the circuit-breakers are of fabricated-steel construction with a domed top plate, while the tank is circular with a dished bottom. The insulators are of the synthetic resin bonded paper condenser bushing type and are fitted with metal gland plates. They can be removed from the circuit-breaker individually and at their lower ends is a contactor block to which the main contact carrier plate is fixed. When the current rating does not exceed 800 amperes the contacts are of the plug-and-socket type, but on the larger sizes additional main contacts of the wedge and finger type are fitted, each finger being provided with an independent backing spring. The moving contact bars are actuated by laminated wood rods, which are attached to a horizontal steel crosshead. This crosshead is arranged to move vertically and has accelerating spring guide rods at each end. The lower ends of the lifting rods are tied together by a laminated wood bar. The rods themselves move vertically through holes in a horizontal steel guide beam to the underside of which dash pots are fitted. These dash pots are filled automatically with oil from the tank when it is bolted in position. When the circuit-breaker is closed accelerating springs at each end of the crosshead are compressed. Buffer springs are also provided at the centre of the crosshead to check it during the closing stroke. Operation may be either by solenoid or spring closing mechanism, which is trip-free in any position of the closing stroke. The circuit-breakers are provided with self-aligning flexible isolating sockets, which are inserted in insulators and screwed into the contact block.

A full series of interlocks is fitted so that it is impossible to make or break load on the isolating plugs; to close the breaker before the isolating plugs are fully engaged; to remove the tank when the breaker is "plugged home" or to replace the breaker unless the tank is in position. A motor-operated raising and lowering mechanism is provided and to prevent accidental contact with live parts as the breaker is lowered each set of spouts is automatically screened by an earthed metal cover. During testing and maintenance both the 'bus-bar and feeder spout covers can be independently locked in the open or closed position. The fixed portions of the isolators are embedded in Bakelite insulators and consist of removable plugs screwed into terminal blocks, to which the feeders or 'bus-bars are connected. The isolator sockets are integral with the circuit-breaker bushing. The 'bus-bars and primary connections are of hard-drawn copper, which is Bakelised where it passes through the barriers. Four wheels on roller bearings are fitted to the circuit-breaker top plate and rest upon the top rail of the supporting carriage. To transfer the breaker it is therefore only necessary to lower it to the isolated position and move it under the other set of bars. The raising and lowering mechanism consists of worm gearing driving screws which are integral with the supporting framework. This framework is of fabricated steel and is arranged to provide complete metal division between adjacent units. There is a common supporting pedestal between adjacent units so that, it is claimed, considerable economy in space is effected in the length of the board.

The principal exhibit on the stand of Messrs. Alfred Herbert, Limited, Coventry, was the 150-ton press illustrated in Fig, 35 on this page. This press, which is of the down-stroke type, was manufactured by Messrs. T. H. and J. Daniels, Limited, Stroud, Gloucestershire, and is used for moulding plastics. The main ram, which has a diameter of 14 in. and a stroke of 18 in., is of close-grained cast iron and is finish-ground to size. The cylinder is a steel casting and is supported by four machined columns, which also serve as guides for the ram and top table. The tables themselves are of cast-iron and are provided with T-slots for securing the platens, the width of the table between the columns being 28 in. and the depth 30 in. Two return rams and cylinders are fitted, one on each side of the press, the return rams having a diameter of 3 in.; like the main rams, they are fitted with easily replaceable glands. A self-contained pumping unit is mounted on the main cylinder casting and the main and return rams are controlled by one valve of the single-lever piston type, the valve being arranged so that it cannot be operated when the front guard is open. Steam, gas or electrically-heated platens are available with the press, the maximum distance between the top and bottom platens being 22 in. when gas-heated platens are fitted and 28 in. when steam or electrically-heated platens are fitted; in each case the platens are 26 in. square.

Examples of the well-known "Besco" range of sheet-metal working machines were shown on the stand of Messrs. F. J. Edwards, Limited, 359 and 361, Euston-road, London, N.W.1. Punching, shearing, cropping and notching machines, presses, guillotines and several other types were exhibited. A recent addition to the range, a universal nibbling and shearing machine with a fabricated steel body for mounting directly to the floor, is illustrated in Fig. 36, on page 510. It is designed for cutting almost any shape in mild-steel plate up to $\frac{1}{8}$ in. thick, by means of a nibbling punch and die, or by shearing cutters, at an average rate of feed of 6 ft. per minute. Plate can be sheared on an inside edge without preliminary punching or drilling. The machine is driven by a $1\frac{1}{2}$-h.p. motor, which runs at 1,425 r.p.m., and drives the upper-cutter ram through step-coned V-rope pulleys, which provide three alternative speeds: 1,425, 1,030 and 740 strokes per minute. The stroke of the ram may be adjusted to suit the thickness of metal. The head is mounted on ball bearings and may be rotated 360 deg. for cutting in any direction. Tecalemit lubrication and a drip-feed unit for cooling the nibbling punch and die are provided. The machine is supplied with two shearing cutters with a lower cutting disc and nibbling die, three nibbling punches and two work-support tables. An attachment for facilitating the cutting of discs, rings and segments can also be provided, as shown in Fig. 36. It consists of two beds in the throat of the machine, one of which is bolted to the bottom and carries a pad, and the other to the top and carries a "dead" centre. The plate to be cut into a disc, ring or

segment is pivoted about this centre, the position of which may be adjusted to suit the radius of cutting. The cutters, or the punch and die, may be used for this work. A template may be used in conjunction with the punch and die. The principal dimensions of the machine are: depth of throat, 3 ft. 6 in.; overall length, 5 ft. 10 in.; height, 6 ft. 8 in.; and width, 1 ft. 10 in. With the centring attachment, discs and rings up to 3 ft. 6 in. in diameter, and segments up to 2 ft. 10 in. radius, may be cut.

Among the Jones cranes, which are made by K. and L. Steelfounders and Engineers, Limited, Coborn Works, Letchworth, Hertfordshire, were the "Super 100" shunting crane, which runs on standard-gauge railway tracks and will lift 5 tons; and the "Super" No. 44, 22 and 15 cranes, which are mounted on four road wheels. Woodworking machines manufactured by Metalclad, Limited, Neath, Glamorgan, included a hand planing, jointing, rebating and moulding machine, and a bandsaw with a depth of cut of 12 in. Messrs. George Cohen, Sons and Company, Limited, Sunbeam-road, London, N.W.10, exhibited several metal-working machines, of which the Coborn-Wadley Type D.E.P.S.24 universal punching, shearing, cropping and notching machine was one of the most recently introduced. It is illustrated in Fig. 37, on this page, with the punching element in the left foreground, the notching element above, the shears in the right background, and the bar, angle and T-section cropping members in the body of the machine. Plates $\frac{5}{8}$ in. in thickness can be punched with holes up to $\frac{3}{4}$ in. in diameter, and by means of a handwheel the punch may be brought down on to the plate, prior to punching, to ensure accuracy. Notching up to 2 in. by 2 in., square or V, and shearing of plates up to $\frac{5}{8}$ in. in thickness can be carried out. The cropping part of the machine will take a variety of sections: 3 in. by $\frac{7}{8}$ in. bar, angles or T-sections 3 in. by 3 in. by $\frac{3}{4}$ in., angles or T-sections $2\frac{3}{4}$ in. by $2\frac{3}{4}$ in. at 45 deg., and $1\frac{1}{4}$ in. round or square bars. The machine is driven by a 5-h.p. motor which is coupled to the flywheel by V-belts on one side of the frame. On the other side, there are two sets of double-reduction gears, each with a hand-operated clutch, driving the punching and notching section and the shearing and cropping section. The machine is fabricated from 2-in. mild-steel plate with $2\frac{1}{2}$-in. spacer plates. Lubrication of the whole machine is by means of a hand grease-gun applied to several Tecalemit nipples which are centrally mounted.

An interesting exhibit on the stand of Messrs. Wessex Industries (Poole), Limited, Poole, Dorset, was the "Wrigley" single-wheel hoe illustrated in Fig. 38, on this page. The most striking feature of this hoe is its low overall width which, at wheel centre, is only 10 in., thus enabling it to be used among growing crops. It is fitted with a J.A.P. 1 h.p. single-cylinder air-cooled petrol engine with a capacity of 98 cubic centimetres. The engine is fitted with a flywheel magneto and is provided with an adjustable governor, which can be set to control the landspeed between the limits of 1 and 3 m.p.h. As will be seen from the illustration, the engine is located inside the single land wheel and is arranged so that the centre line of the crankshaft is at right angles to the axis of the wheel. The drive from the engine is transmitted through a flexible coupling to a worm-reduction unit and then by twin V-belts to a large pulley fitted to the axle of the landwheel. The V-belts are held in the correct tension by a spring loaded jockey wheel and the reduction unit is fitted with a power take-off shaft. The clutch is operated by a twistgrip control incorporated in one of the handles. This arrangement allows the machine to be driven away without removing either hand from the steering handles. The frame, which is built up from heavy-gauge steel tubing, forms an underslung cradle to which the engine and reduction unit are attached, the frame being suspended from the axle of the landwheel. The handles are bolted to the underslung frame and in addition to being adjustable for height, are provided with a folding stand for supporting the machine when changing implements. The landwheel is of welded steel construction and has a diameter of 25 in., the width being 4 in. The machine has an overall length of 66 in., and an overall height of 34 in., while the width across the handles is 19 in. The weight, in working order, is only 120 lb. and it can be transported, therefore, in a light-car type of trailer. The standard machine is fitted with a pair of 6-in. hoes and extra equipment available includes 4 in. and 8-in. hoes, left- and right-hand ploughs for earthing up, a baulking plough for ridging and extra toolbars and frames to give additional tool mountings for working multi rows.

A new four-wheeled light tractor was included among the exhibits on the stand of Messrs. Tractors (London) Limited, The White House, Bentley Heath, Barnet, Hertfordshire. The tractor is illustrated in Fig. 39, opposite, and it has been designed so that it can be used with equal facility for both agricultural and industrial purposes. Its design is based largely on the "Trusty" two-wheeled agricultural tractor, an illustrated description of which was given in ENGINEERING, page 53, of our 164th volume, (1947), and for this reason it has been designated the "Trusty Steed." It is powered by a Norton single-cylinder, air-cooled petrol engine developing a maximum of 13·5 brake horse-power. A centrifugal type clutch is fitted directly to the engine crankshaft and the drive is transmitted from the clutch to the transmission countershaft through sprockets and a roller chain. The tractor is provided with a single forward speed and reverse, the speed in forward gear ranging from 1·7 to 10 miles an hour. Car-type steering is fitted to the front wheels and steering can be assisted by disengaging the drive to the relevant rear wheel; when power steering is employed, the turning-circle radius is 14 ft. This is accomplished through dog clutches fitted to the countershaft and operated by a small lever fitted beside the driver's seat. This lever is called the "joy-stick" control, and in addition to disconnecting the drive to the rear wheels, is used to select forward and reverse directions of travel. To select forward and reverse, the lever is moved towards the front and rear of the tractor respectively; when the lever is moved through 45 deg. to either side, however, it disengages the drive to that side towards which it is moved, and if it is moved beyond 45 deg., both dog clutches are released and both driving wheels freed. Braking of the tractor is effected by a transmission brake which is arranged for both foot and hand operation. The tractor has a minimum ground clearance of 8 in. and can haul a load of 2 tons.

Messrs. E. Boydell and Company Limited, Elsinore-road, Old Trafford, Manchester, were show-

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

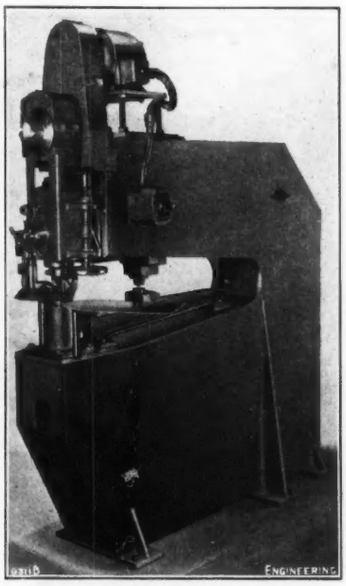


FIG. 36. NIBBLING AND SHEARING MACHINE; MESSRS. F. J. EDWARDS, LIMITED.

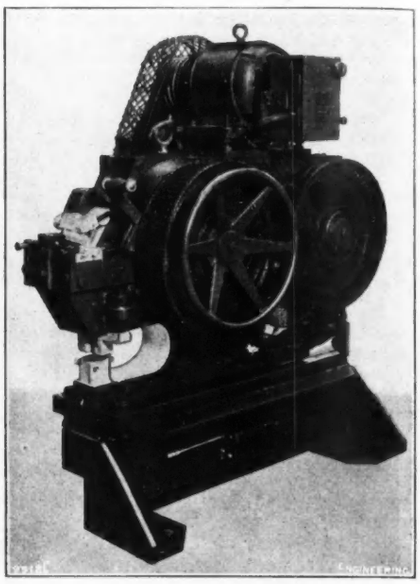


FIG. 37. PUNCHING AND SHEARING MACHINE; MESSRS. GEORGE COHEN, SONS AND COMPANY, LIMITED.

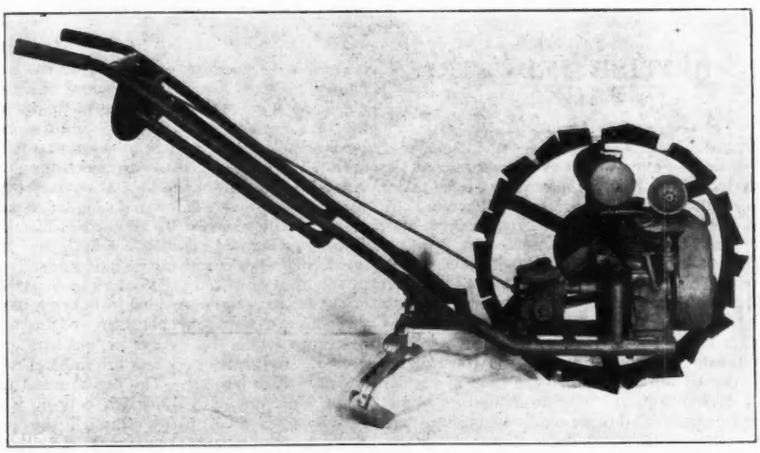


FIG. 38. SINGLE-WHEEL MOTOR HOE; WESSEX INDUSTRIES (POOLE), LIMITED.

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

FIG. 39. "TRUSTY STEED" TRACTOR; MESSRS. TRACTORS (LONDON), LIMITED.

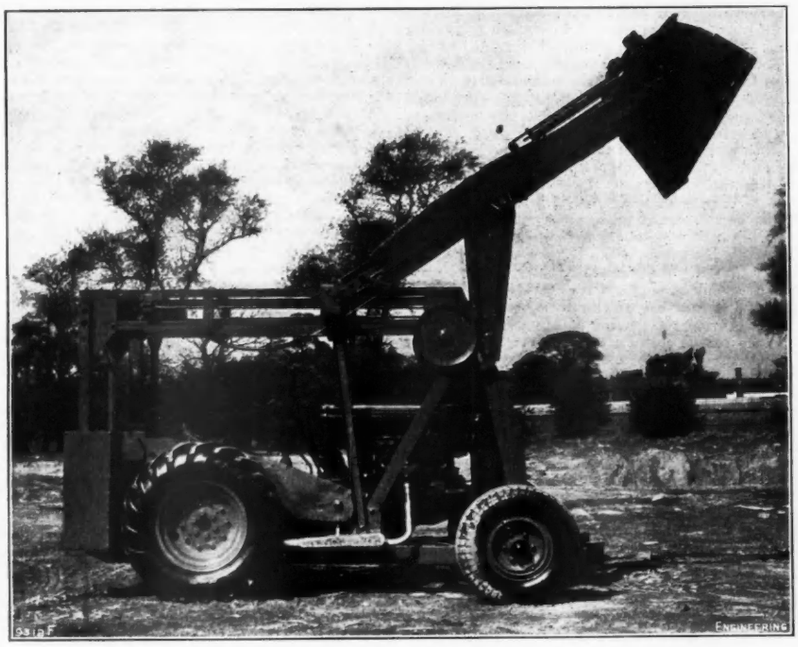


FIG. 40. ⅜-CUB. YD. LOADER; MESSRS. E. BOYDELL AND COMPANY, LIMITED.

ing a range of Muir-Hill dumpers and their latest design of Muir-Hill loader. The loader is illustraten in Fig. 40, on this page, where the bucket is shown elevated to the full extent. The standard bucket has a capacity of ⅜ cubic yard and the machine is capable of loading over the side of a vehicle or hopper 12 ft. high. Obviously, one of the difficulties encountered in designing a machine of this type is to obtain good stability but at the same time to keep the wheelbase and track within reasonable limits. Good stability on the Muir-Hill loader has been achieved by adopting what can best be described as double articulation, the engine, transmission, winch and driving axle forming a single rigid assembly, centre mounted at the front while the frame, the jib and the rope gear are carried on two-point suspension at the front and centre mounted at the rear. The machine is fitted with a four-cylinder petrol engine having a bore and stroke of 4½ in. and 5 in., respectively. The drive from the engine is transmitted through a single-plate, oil-immersed clutch to a three-speed constant-mesh gearbox. The driving axle is of the double-reduction type, the differential being fitted into the first stage of reduction so as to reduce the loading on the gears. The axle shafts rotate in taper-roller bearings and are provided with integral flanges for the attachment of the driving wheels. The front axle is integral with the frame and is fitted with car-type steering operated by a cam-and-roller type steering box. The road wheels are of the detachable disc type and the rear wheels are fitted with 12 in. × 24 in. land-type tyres, while the front wheels are fitted with 9 in. × 16 in. road tyres. Girling internal-expanding brakes, having a diameter of 16 in. and a width of 2½ in., are fitted to the rear wheels only but a transmission brake of the oil-immersed multi-plate disc type is fitted as well. The frame of the loader is built up from rolled-steel channels and angle sections while the lifting beams are of box section fabricated-steel construction. The winch is driven by a roller chain and is fitted with a $\frac{7}{16}$ in. diameter rope. The winch rope, however, does not pull directly on the front lifting arms but is connected to the centre of a horizontal compensating beam, the ends of which are connected by further ropes to the lower ends of the lifting arms. The ropes connecting the compensating beam to the lifting arms pass over large fairlead pulleys, one of which can be seen in the illustration. The winch is fitted with brakes which are arranged so that they are applied automatically as the bucket approaches ground level thus preventing the winch rope from slackening and subsequent snatch when the load is lifted. The bucket is fitted with wearing strips and is provided with an automatic setting gear; it can be tipped, however, at any height within the maximum lift. With the bucket on the ground, the machine has a length of 16 ft. 6 in., a width of 6 ft. 6 in. and a height of 7 ft. 11 in., while the height to the underside of the bucket when raised to its full extent is 12 ft. As previously mentioned, the bucket has a capacity of ⅜ cubic yard but a larger bucket for use with light materials can be fitted.

The Quasi-Arc Company, Limited, Bilston, Staffordshire, were showing a representative selection of their welding sets, electrodes and accessories. Among these mention may be made of the DE 300 Diesel-engine driven portable set. This consists of a 22·5-h.p. two-cylinder Ruston engine running at 1,500 r.p.m., which is arranged for hand starting and is coupled through a flange to a drooping characteristic direct-current generator. It is claimed that this method of construction, besides ensuring maximum rigidity and accurate alignment, leads to compactness and simplifies re-assembly after overhaul. Dual control is incorporated in the set, the striking voltage and welding current being independently variable, so that the operator can choose the values, which are desirable for the work in hand. This is effected simply by turning the voltage hand-wheel pointer to the class of work and then regulating the current in the normal way. Diverter control provides stepless regulation of the welding current, while fine control of the open circuit voltage is possible. The set is available as a stationary unit or can be mounted on four wheels with a swivelling front axle and front draw bar. Alternatively, the equipment can take the form of a trailer unit mounted on two wheels with pneumatic tyres, tow bar, overrun brakes and parking jacks. A 16-gallon fuel tank is mounted under the roof of the set and provides for about 16 hours running.

A built-up crankshaft weighing 55 tons was exhibited on the stand of Messrs. Walter Somers, Limited, Haywood Forge, Halesowen, near Birmingham. It is the twelfth to be finished by the firm since they took up this type of work in 1945, and is intended for a four-cylinder N.E.M.-Doxford engine which has been designed to develop 5,000 h.p. The crankshaft is built up of 19 forged pieces, shrunk together without dowels or keys. It is 40 ft. 6 in. in length overall, the diameter of the pins and journals is 1 ft. 8 in., and the strokes are 2 ft. 2½ in. for the centre pins and 1 ft. 7½ in. for the side pins. The tolerance allowed on all diameters was ±0·004 in. In the alignment, angularity and strokes of the crankpins, the permissible error over the whole of the crankshaft was 0·020 in., but the permissible error for each cylinder was 0·004 in. The crankshaft required one 60-ton ingot, one 50-ton ingot, and two 40-ton ingots, which, with several smaller pieces, gave a total weight of approximately 220 tons of ingot steel.

The exhibit of the British Iron and Steel Federation, Steel House, Tothill-street, London, S.W.1, was designed primarily as an information centre and as such provided a great deal of useful data both for technical and non-technical visitors It consisted essentially of pictorial displays, which clearly indicated the extent, location, production and development schemes of the industry. As regards development, the contemplated plan for expansion during the next four years provides for an additional 1,780,000 tons of blast furnace capacity, 1,850,000 tons of steel furnace capacity, and 1,475,000 tons of cogging and finish mill capacity, as well as the essential ancillary plant. The increase in steel production during the past decade, together with the related rise in home consumption, and indirect and direct exports, was illustrated on a number of panels. During the Fair, demonstrations were given of the spectroscopic examination of steel and the applications of X-ray equipment in

the detection of flaws. It is a matter of interest that the industry spends about 1,500,000*l.* per annum on research.

Among the heat control and measuring equipment, which were exhibited by Ether, Limited, Tyburn-road, Erdington, Birmingham, 24, mention may be made of the "Wide-Strip" recording potentiometer. This is designed not only for indicating and recording, but for providing on-off, high-low and multi-position proportional control. The readings are independent of the external circuit resistance and the scale can be calibrated to measure temperature, millivolts, milliamperes or gas flow. As the instrument is electronically operated throughout, there is no need for a galvanometer. The potentiometer element consists of a twin-slide wire with a total length of 20 in., and is mounted immediately behind the chart. The slide wire acts as a track for the carriage holding the recording pen, so that there is no error due to backlash. In operation the direct-current out-of-balance potential from the slide-wire contact is fed into a magnetic inverter, which converts it into alternating-current potential and at the same time amplifies it to about 230 volts. The final stage of the amplifier embodies a phase-shifting device from which the output is fed into a two-phase motor. This motor drives the pen up or down the scale so as to eliminate the out-of-balance signal received from the slide wire. While the normal instrument has a speed of travel across the chart of 28 seconds, this can be reduced to as little as 2 seconds. This instrument can be calibrated for a full-scale deflection of 10 millivolts and is designed to detect an out-of-balance slide wire potential of as little as 0·002 millivolts. For scale ranges of 10 millivolts and above, the overall error is claimed to be about 0·2 per cent. An inherent property of the circuit is that within wide limits the external resistance has no effect on the accuracy of the instrument.

Another exhibit on the same stand was an improved pattern of the firm's continuous recording and controlling pyrometer. This is of the chopper-bar direct-deflectional type with a chart width of 5 in. and chart speed which can be varied between ½ in. and 6 in. per hour. Thermocouples, radiation tubes and resistance bulbs are used in conjunction with this instrument over a temperature range of −200 deg. to +2,000 deg. C., and a full range of electrically-operated valves is available to adapt it to the control of gas-oil and other furnaces.

STREAMLINED RAILWAY CARRIAGES.—The Railway Executive, Eastern and North Eastern Regions, state that most of the carriages which formed the pre-war L.N.E.R. streamlined expresses, "Silver Jubilee," "Coronation" and "West Riding Limited," will be brought back into traffic, in their distinctive liveries, on Monday, May 31, when the summer services begin.

MOTORSHIPS FOR HOLYHEAD-KINGSTOWN SERVICE.—The first of two new passenger and cargo motorships now under construction at the Belfast shipyard of Messrs. Harland and Wolff, Limited, for the Holyhead-Kingstown service of British Railways (London Midland Region), will be ready for launching in July. As it is proposed to name this ship the Hibernia and her sister vessel the Cambria, application has been made to the Minister of Transport for permission to change the names of the ships at present bearing them to Hibernia II and Cambria II. The gross tonnage of the new motorships is 5,200, and each will have a passenger capacity of 2,000. Each vessel will be nearly 400 ft. long and will have a speed of 21 knots.

ENGINEERING AND INDUSTRIAL EQUIPMENT (HOME AND EXPORT) EXHIBITION.—An exhibition, organised by the British Bulletin of Commerce, was opened on Wednesday, May 19, in the Old Horticultural Hall, Vincent-square, London, S.W.1. The exhibition covers a wide range of light engineering products, and includes machine tools, radio and electrical components, electric motors, welding equipment, and exhibits which show developments in the refrigerating and catering industries. Models illustrating methods of construction in sheet steel are also on view, together with exhibits showing various enamel finishes. Among the domestic equipment shown are new forms of oil heating stoves. The exhibition closes to-day at 4 p.m.

GENERAL-PURPOSE LIGHT CAR.

MESSRS. ROVER COMPANY, LIMITED, BIRMINGHAM.

GENERAL-PURPOSE LIGHT CAR.

EXPERIENCE gained during the recent war with four-wheel drive light vehicles showed that there would be a wide field for their employment in civilian capacities, particularly on farms. As a result, Messrs. Rover Co., Ltd., Solihull, Birmingham, have produced the general-purpose four-wheel drive vehicle designated the Land Rover, which is illustrated on this page. Although designed primarily as a farm vehicle, its usefulness is by no means limited to agriculture as it can be fitted with a central power take-off for driving machinery, such as an air compressor or a welding set installed in the body of the vehicle. Furthermore, the vehicle develops a drawbar pull of from 1,200 lb. to 1,800 lb., and it should prove useful, therefore, as an inter-works tractor as, apart from hauling a train of trucks within the works, it can be used also for general transport duties. Its versatility can be increased further by fitting an engine-driven capstan-type winch to the front bumper bar which can be used for various jobs ranging from the moving of heavy machinery to hauling the vehicle out of a bogged-down situation.

With the exception of a reduction in the compression ratio, the engine fitted to the Land Rover is the same as that fitted to the Rover "60" car. It is a four-cylinder unit having a bore and stroke of 69·5 mm. and 105 mm., respectively, and developing 50 brake horsepower. It is fitted with overhead inlet and side exhaust valves, the exhaust valves being set in the cylinder block at an angle of 55 deg. to the vertical and operated through rocking levers situated above and to one side of the camshaft. The inlet valves are fitted to the cylinder head and are operated through a system of push rods and rocking levers from the same camshaft as the exhaust valves. In order to accommodate this unusual valve arrangement, the joint between the cylinder block and the head is made at an angle of 20 deg. to the horizontal. Apart from the arrangement of the valves, the engine is of orthodox construction. The crankshaft runs in three main bearings which, together with the big-end bearings, are of the steel-backed white-metal lined type. Aluminium pistons are fitted, the crowns being shaped in the form of an inverted V so as to conform to the shape of the combustion chambers, and each piston is fitted with two compression and two oil-control rings. The camshaft is of cast iron with chilled faces and is driven by a double-roller silent chain from the front end of the crankshaft. A Solex down-draught carburettor is fitted, and as the valve arrangement results in the induction and exhaust manifolds being on opposite sides of the engine and prevents, therefore, the formation of the usual type of hot spot, the induction manifold is provided with a water jacket. The Solex carburettor incorporates the usual economy device and accelerating pump, and all air entering the engine is filtered by a large oil-bath type of air cleaner; this is fitted to the chassis superstructure and is free, therefore, from engine vibration. All bearings within the engine, with the exception of the small ends of the connecting rods, are supplied with oil under pressure from a gear-type pump which draws oil from a sump having a capacity of 10 pints; the small end bushes and the cylinder walls are lubricated by oil jets from the big ends. The cooling water is circulated by a centrifugal-type pump, the temperature of the engine being thermostatically controlled, and engine cooling is assisted by a fan situated behind the radiator and driven from the forward end of the crankshaft through a V belt. The fan belt is used also to drive the dynamo, which is fitted to the engine so that it can be pivoted about its bracket so as to adjust the tension of the belt.

The drive from the engine is transmitted to the gearbox through a single dry-plate clutch, the clutch housing and gearbox casing forming a single unit with the engine. The gearbox is a four-speed unit, the ratios for the various gears being: first 3·00 to 1, second 2·04 to 1, third 1·47 to 1 and top 1 to 1. The transfer gearbox is fitted directly to the rear of the main gearbox; in addition to transmitting the drive to the front and rear axles, this unit also provides two alternative gear ratios which, in conjunction with the main gearbox, give a total of eight forward speeds, the ratios of the two gear trains in the transfer box being 2·888 to 1 and 1·146 to 1 for low and high ranges, respectively. The transfer box is arranged so that the final drive to the two axles is brought towards the right-hand side of the vehicle and thus allows the propeller shaft for driving the front axle to pass along the side of the engine. Front-wheel drive is obtained by engagement of a dog clutch, and in order to prevent torsional strains being set up in the transmission shafting, a free-wheel is interposed between the front axle and the transfer box. This allows the front wheels to over-run the rear wheels when the vehicle is driven round bends with all wheels driving, but an interlock is provided so that the free-wheel can be locked when four-wheel drive is required in reverse gear.

The drive from the transfer box is transmitted to the front and rear axles through open propeller shafts, the torque being taken by the springs. The front and rear axles are similar in construction, both being fitted with spiral-bevel final drives having a ratio of 4·88 to 1. The front axle, of course, is fitted with constant-velocity universal joints at each end; these are fully enclosed, the oil level of each being maintained through combined oil-level and filler plugs. Oil seals are fitted between the universal-joint housings and the axle ends so as to prevent transference of oil and subsequent starvation of the upper housing when one road wheel runs lower than the other; for example, when ploughing. The road springs are of the semi-elliptical pattern and work in conjunction with telescopic hydraulic shock absorbers, the spring eyes, etc., being fitted with rubber bushes. The chassis frame is of all-welded construction, the side members, which are of box section, having a depth of 6 in. at the centre and a width of 3 in. Five box-section cross members are fitted and the two end cross members are extended to the full width of the vehicle so that they can act as bumper bars. The chassis frame is galvanised and has been designed so that either left- or right-hand steering may be fitted with equal facility. Girling hydraulic brakes are fitted to all wheels, the effective diameter and width of the brake linings being 10 in. and 1¼ in., respectively. A Girling hand-operated transmission brake also is fitted; this is mounted on an extension of the final-drive shaft of the transfer box and due to the action of the free-wheel, acts on the rear wheels only. Detachable disc wheels are fitted and these are equipped with 16 in. × 6·00 in. heavy-duty traction-type tyres.

As previously mentioned, arrangements have been made for driving machinery installed in the body of the vehicle, and a capstan-type winch fitted to the front bumper bar. In the former case, the power is obtained from a pulley fitted immediately behind the main gearbox, while in the latter case the drive is taken from the

LAND-CLEARANCE EQUIPMENT FOR EAST AFRICA.

FIG. 1. THE "SHERVICK" HEAVY TRACTOR.

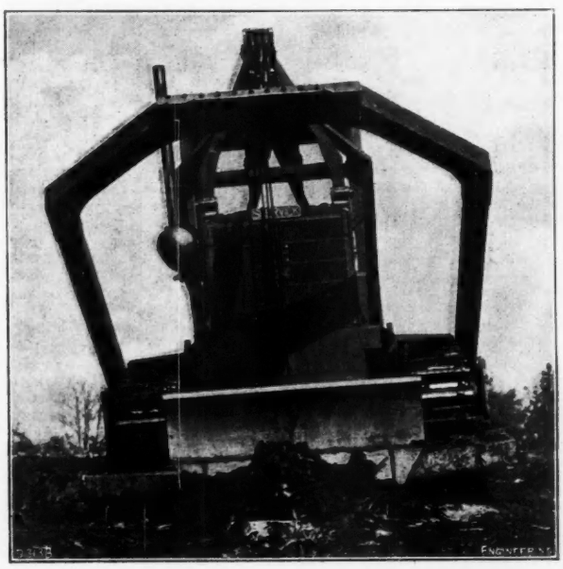


FIG. 2. TRACTOR AND TREE-FELLING EQUIPMENT.

forward end of the crankshaft through a worm reduction gear. In addition, a third power take-off point is provided at the rear of the vehicle and this can be arranged for belt drive, or for a straight-through drive, as on farm tractors, for driving power mowers, combines, etc. The rear power take-off is driven through shafting from the rear of the main gearbox and the drive is transferred to the pulley through spiral-bevel gearing. The standard unit is fitted with a flat pulley wheel having a diameter and width of 8 in.

With the exception of certain additions used in connection with the auxiliary equipment, the controls fitted to the Land Rover generally are similar to those fitted to a standard vehicle. The additional controls consist of three push-pull knobs which protrude from the dashboard and control the transfer-box ratio, the free-wheel lock and the engagement of the front-wheel drive, while a lever situated beside the driver's seat is used to engage the rear power take-off. The bodywork is of composite steel and aluminium-alloy construction, all steelwork being galvanised as a protection against corrosion. The wheelbase is 6 ft. 8 in. and the track 4 ft. 2 in., while the overall length and breadth of the complete vehicle is 11 ft. and 5 ft., respectively. The vehicle is well fitted out, the equipment including side, head and tail lamps, a speedometer, a petrol gauge and an ammeter. A noteworthy feature is the provision of warning lights for the engine-lubrication system, the ignition system and the carburettor choke, the last-named light showing so long as the choke is in action. Although the vehicle illustrated is not fitted with any form of weather protection, fabric hoods for covering either the complete vehicle or the driving compartment only are available.

RENOVATION OF WEMBLEY STADIUM STATION.—During the war, the station, which was specially built in 1924 to serve the Wembley Stadium, became delapidated. It has been renovated recently in preparation for the Olympic Games, which are being held this summer, and the work was completed in time for the Football Association Cup Final match on April 24. The station is served by a single-line loop which leaves the main line out of Marylebone near Neasden, and as many as 21 trains—the number used for the Cup Final in 1939—can be run to the station and cleared round the loop to bring spectators to the match.

GOVERNMENT SALES OF MACHINE TOOLS.—Since the commencement of disposals operations three years ago, 200,000 machine tools, to the value of 43,000,000*l.*, have been sold by the Ministry of Supply, who still have approximately 20,000 machines stored at various depots throughout the country in readiness for future sales. With a few exceptions the majority of these machines can be bought for export, either by British firms or by foreign buyers. The ultimate objective of the disposals scheme is to enable British industry to re-equip its workshops with good tools at a reasonable price, and for which there is no delay in delivery.

LAND-CLEARANCE EQUIPMENT FOR EAST AFRICA.

ONE of the major problems associated with the development of the Overseas Food Corporation's East African Ground-nuts Scheme is the removal of trees, undergrowth and scrub from the proposed plantations. In addition to removing the trees, etc., the ground must be cleared of roots and subsequently rendered suitable for agricultural purposes. It was realised from the outset, therefore, that the undertaking called for the extensive use of heavy tracked tractors and special ground clearing implements, neither of which were available in this country. An obvious alternative source of supply was the United States but it soon became apparent that even if the dollars were forthcoming, delivery of the tractors and ancillary equipment would not commence before 1950, or even later, by which time, of course, it was hoped that the project would have reached an advanced state. It was decided therefore, that the Sherman Mark III tank, of which there is a plentiful supply in this country, should be used as the basis for a new tractor. The conversion was undertaken by Messrs. Vickers-Armstrongs Ltd., Broadway, London, S.W.1, and the development work was carried out at their Chertsey works. Although the specification was only agreed in October 21, 1947, the first tractor was completed by January 2, 1948, a creditable achievement, especially as no major modifications were found necessary after extensive field trials. The tractor has proved so successful that large-scale production has already commenced. They are being manufactured at Messrs. Vickers-Armstrongs' Elswick Works, Newcastle-on-Tyne, the number depending on the quantity of tanks available.

One of the completed tractors, which has been designated the Shervick, is illustrated in Fig. 1, on this page, from which it will be seen that it bears little resemblance to the Sherman tank. The principal components of the standard Mark III Sherman tank used in its construction comprise the combined gearbox and transmission, one of the two General Motors type 671 engine and clutch assemblies, one of the radiators, four of the six bogie suspension units and the tracks. The frame of the Shervick tractor is entirely new and is of all-welded steel construction. It is shaped in the form of a punt and comprises a floor, side plates, which are flanged at their tops, and box-section cross members. One of the box-section cross members runs across the front of the tractor and the other at approximately the centre position, the latter being extended at each side so that it can act as an anchor for the implements. The ends of this cross member terminate in flanges, one of which can be seen in Fig. 1. A cross member is not fitted to the rear of the frame as the transmission housing extends across the full width of the frame.

The power unit, as previously mentioned, is one of the two General Motors engines fitted to the Sherman tank. It is a six-cylinder two-cycle Diesel unit having a bore and stroke of 4½ in. and 5 in., respectively, which gives a displacement of 425 cub. in. Scavenge air is supplied by a Root's blower, the air entering the cylinders in the usual manner through ports formed in the cylinder liners. The exhaust gases, however, are discharged through valves in the cylinder head, there being two exhaust valves for each cylinder. The cylinder head is detachable and in addition to the exhaust valves, is fitted with the fuel injectors; these occupy the central position in each cylinder and are located between the exhaust valves. The injectors are of General Motors standard pattern and may be described as combined fuel-metering pumps and spray valves. The pumping elements are operated by the camshaft through rocker arms and the delivery from each pump is regulated in the usual manner by an integral rack and pinion. The cylinder block and crankcase form a single casting and the cylinder bores are fitted with removable liners. The crankshaft is made from high-carbon manganese steel and is carried by seven main bearings of the copper-lead steel-backed type. The pistons are of malleable iron and each is fitted with four compression and two oil-control rings. The pistons are held to the connecting rods by fully-floating gudgeon pins which work in bronze bushes, the connecting rods being drilled for lubrication of the gudgeon-pin bushes and cooling of the piston crowns. A centrifugal governor is fitted which controls the maximum and idling speeds of the engine; when fitted to the Sherman tank, the engine was governed to a maximum speed of 2,100 r.p.m., but for the Shervick tractor, this has been reduced to 1,500 r.p.m., at which speed the engine develops approximately 170 brake horse-power. Naturally, the existing engine auxiliaries have been used so far as possible and the Shervick tractor is fitted with the original fan and its drive, fuel and oil filters, air cleaners and one of the radiators; the radiator, however, has been fitted with a new header tank, but the radiator guard has been adapted from the bullet-proof louvres fitted to the Sherman air intakes. In addition to the auxiliaries already mentioned, the original starter motor and dynamo has been used, but a plug-in connection has been provided so that the tractors can be started from a slave-battery truck.

The drive from the engine is transmitted to a transfer gearbox through the original General Motors clutch; this is of the dry-plate type and has a diameter of 16 in. The transfer gearbox is a new assembly and in addition to giving a reduction ratio between the engine and main gearbox of 2 to 1, provides a power take-off point for driving the winch. The transfer box is fitted with helical gears, the existing Sherman transfer gears, shafts, bearings, etc., having been used where possible. The casing is a fabricated-steel structure which is bolted directly to the flywheel housing of the engine, the casing being fitted with brackets which act as rear engine bearers. The engine, clutch and transfer box assembly is supported by pedestals fitted to the floor of the tractor frame, rubber blocks being interposed between the tops of the pedestals and the engine bearers. As previously mentioned, the original Sherman transmission assembly is used to transmit the drive to the tracks. On the Sherman tank, however, the tracks were driven from the front whereas on the Shervick tractor the drive is at the rear, so the transmission assembly has been

turned through 180 deg. The original propeller shaft, complete with Hardy-Spicer universal joints, has been used to transmit the drive from the transfer box to the transmission assembly, but the shaft has been shortened so as to suit the altered relationship between the engine and transmission. The transmission assembly comprises a gearbox, a bevel drive, a differential and two final drives, the final drives consisting of double-helical reduction gears. The gearbox provides five forward speeds and one reverse speed. The gears for all speeds are in constant mesh and synchronisers are fitted to all gears except first and reverse to facilitate gear changing; on the Shervick tractor, however, first speed will not be used as the stresses imposed are considered too high for constant operation. The speeds in the various gears at an engine speed of 1,500 r.p.m. are: second gear, 1·76 miles an hour; third gear, 3·04 miles an hour; fourth gear, 4·95 miles an hour; and top, 7·5 miles an hour. The steering is of the controlled-differential type in which it is impossible to lock one track. New levers and shafts have been fitted to the steering-brake and gear controls, in order to bring them to the new driving position.

Four of the six bogie suspension units fitted to the Sherman tank have been used, there being two units for each track and each unit comprises two volute springs and two rubber-tyred bogie wheels. The springs and wheels are assembled in brackets and the brackets, in turn, are bolted to the side plates of the tractor frame, which are reinforced at the points of attachment. The upper reach of each track is supported by rollers integral with the suspension brackets and the tension of the track is adjusted by altering the position of the forward idler wheels which are fitted to eccentric shafts. The housings for the eccentric shafts are bolted to buttresses formed in the tractor frame, the frame, as a consequence, being narrower at the extreme front. The existing Sherman tracks, suitably shortened, have been used and additional track grip is provided by welding a 1¼-in. square steel bar to each track link.

The design and manufacture of the implements for use with the tractor was entrusted to Messrs. Blaw-Knox Limited, Euston-road, London, N.W.1, who, in the same period occupied in the development of the tractor, have produced a tree feller, a tree stump remover, a root cutter, and a root rake—a remarkable achievement. A frontal view of the tractor equipped with the tree feller and stump remover is shown in Fig. 2, on page 513, and the two implements are shown in use in Figs. 4, 5 and 6, on page 516. It will be seen from Fig. 4 that the tree-feller blade and the stump remover are fitted to two U-frames, which embrace the front of the tractor, the arms of the U-frames pivoting about trunnions fitted to the ends of the extended centre cross member of the tractor. The height of the tree-feller blade and stump remover is regulated by a winch fitted to the rear of the tractor and driven by a shaft from the tractor power take-off. The winch was supplied by Messrs. Blaw-Know, but was fitted to the tractor by Messrs. Vickers-Armstrong during assembly. It has two separate drums, the rope from one drum being connected to the front of the U-frame for the tree feller and the rope from the other drum to the frame for the stump remover, the two ropes passing through a system of pulleys and sheaves fitted to the tractor superstructure. The superstructure was manufactured by Messrs. Blaw-Know and has been designed so that, if required, it can be dismantled from the tractor by the removal of pins. In operation, the tree-felling blade is adjusted to a convenient height and the tractor is driven forward so that the blade makes contact with the trunk of the tree, as shown in Fig. 5, on page 516; full power is then applied and the pressure of the tree-felling blade causes the tree to heel over. Generally the front of the tractor comes against the base of the trunk before the tree has been displaced a sufficient amount to cause it to fall. In such cases, the tractor is reversed and the tree is finally uprooted by using the stump-removing blade as shown in Fig. 6, on page 516, thus accomplishing the actions of felling and stump removal in one operation.

Clearance of the sites in East Africa, however, is by no means confined to the felling of trees as large tracts of ground are covered by bush. Generally, the bush is removed by angledozers and for this reason the blade of the stump remover is fitted to its U-frame by removable pins so that it can be replaced by an angle-dozing blade. After the bush has been cleared by angledozing, heavy intertwined roots are left in the ground and these are broken up by the root cutter previously referred to, after which they are collected into windrows by a large rake, both of these implements being towed behind the tractor. The root cutter is illustrated in Fig. 3, on page 516, which shows it with the cutting tools lifted from the ground. The main frame is of all-welded construction and is built up from box-section girders. It will be seen from the illustration that the frame is cranked so that the trailing portion is higher than the leading portion and that the cutting tools are fitted to the raised portion of the frame. The cutting tools comprise two vertical posts and two disc coulters. The vertical posts have their leading edges ground to a knife edge and fitted to the foot of each post is a horizontal triangular shaped blade, the blades being set at an angle so as to assist in drawing the implements into the ground. Furthermore, the posts are staggered slightly so that the blades can overlap each other and yet leave a clear space for the passage of any uncut roots. The posts are set 4 ft. apart and each triangular blade has a width of 4 ft. 2 in.; the blades, however, overlap by 2 in., so the total width is 8 ft. 2 in.

The working depth of the blades is controlled by landwheels in a manner similar to that employed on agricultural implements generally. A landwheel is fitted at each side of the frame and each rotates about an axle fitted to the shorter arm of a bell-crank lever, the arms of which are set at an angle of 90 deg. The bell-crank levers, in turn, pivot about the main frame and the longer arms are joined at their tops by a bridge piece; the landwheels, the bell crank levers and the bridge piece can be seen in the illustration. The bridge piece is connected through a system of sheaves to one of the winch ropes, and it will be appreciated that if the winch rope is wound in, the frame of the tractor will be raised from the ground and the depth of working altered accordingly.

The root rake is similar in principle to those employed for normal agricultural purposes, but obviously is considerably larger and of more robust construction. It has a width of 16 ft. and is fitted with tines having a length of approximately 4 ft. 6 in., the distance between the tines being 1 ft. The frame is designed so that by using the tractor winch, the tines can be lifted clear of the ground and the roots deposited in windrows. The rake, however, is being developed further as trials have shown the desirability of shorter tines.

So far, all the equipment has been tested in this country alone and difficulty has been experienced in finding a tract of ground of the same nature as that in East Africa. Nevertheless, the trials carried out so far augur well for the future performance of the equipment in East Africa.

BOOKS RECEIVED.

Concrete Materials and Practice. By Dr. L. J. Murdock. Edward Arnold and Company, 41 and 43, Maddox-street, London, W.1. [Price 21*s.* net.]

Circuits and Machines in Electrical Engineering. Volume I. *Circuits.* Volume II. *Machines.* By Professors John O. Kraehenbuehl and Max A. Faucett. Second edition. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York, 16, U.S.A. [Price 4.25 dols. each volume.] Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 25*s.* 6*d.* net each volume.]

Vector and Tensor Analysis. By Professor Louis Brand. John Wiley and Sons, Incorporated, 440, Fourth-avenue, New York, 16, U.S.A. [Price 5.50 dols.] Chapman and Hall, Limited, 37, Essex-street, Strand, London, W.C.2. [Price 33*s.* net.]

University of Illinois. Engineering Experiment Station. Bulletin No. 365. *Experience in Illinois with Joints in Concrete Pavements. An Investigation Conducted by the College of Engineering and the Division of Highways, State of Illinois.* By John S. Crandell and others. [Price 1 dol.] No. 368. *The Effect of Eccentric Loading, Protective Shells, Slenderness Ratios, and Other Variables in Reinforced Concrete Columns.* By Frank E. Richart and others. [Price 1 dol.] No. 369. *Studies of Highway Skew Slab-Bridges with Curbs.* Part I. *Results of Analyses. An Investigation Conducted by the Engineering Experiment Station, the Public Roads Administration, and the Division of Highways, State of Illinois.* By Vernon P. Jensen and John W. Allen. [Price 75 cents.] No. 370. *The Illinois Smokeless Furnace.* By Julian R. Fellows, Alonzo P. Kratz and Seichi Konzo. [Price 75 cents.] The Director, Engineering Experiment Station, University of Illinois, Urbana, Illinois, U.S.A.

University of Illinois. Engineering Experiment Station. Circular No. 52. *The Railroad Dynamometer Car of the University of Illinois and the Illinois Central Railroad.* By Professor John K. Tuthill. The Director, Engineering Experiment Station, University of Illinois, Urbana, Illinois, U.S.A. [Price 20 cents.]

Pelican Books Series. The Inventor and His World. By H. Stafford Hatfield. Penguin Books, West Drayton, Middlesex. [Price 1*s.* 6*d.* net.]

Training in Foremanship and Management. By James J. Gillespie. Fifth edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 12*s.* 6*d.* net.]

Industrial Diamond Review. Six Years' Index. 1940-1946. Editor: A. Tremayne. Technical Editor: P. Grodzinski. N.A.G. Press, Limited, 226, Latymer-court, Hammersmith, London, W.1. [Price 3*s.*]

PERSONAL.

Mr. Charles Greenwood, M.I.C.E., City Engineer and Surveyor of Chester, is to be the next President of the Institution of Municipal Engineers, which, this year, celebrates the 75th anniversary of its formation. He will succeed Major J. B. L. Thompson, M.C., M.I.C.E., Borough Surveyor of Swindon, at the annual meeting of the Institution, to be held in Scarborough on June 2.

Mr. F. Wardrobe, A.M.I.E.E., has retired from the position of chief engineer of Messrs. William Jessop and Sons, Limited, Brightside Works, Sheffield, 1. He remains a director of the company and will continue to act as a consultant on plant and engineering developments.

Mr. Herbert Asbridge, who for over 20 years has been works manager with the Churchill Machine Tool Company, Limited, Broadheath, near Manchester, is retiring at the end of the present month. He has been associated for nearly 50 years, first with Charles Churchill and Company, Limited, and later with the present firm.

Mr. H. A. Cochran, B.Sc. (Min.) (Glas.), M.Inst.M.M., F.G.S., has been appointed Chief Inspector of Mines, Nigeria. He has held the position of Deputy Chief Inspector of Mines for some years.

Mr. H. T. Scott has recently been appointed honorary secretary of the East Midlands branch of the Institution of Heating and Ventilating Engineers. Mr. R. C. Dick has been made honorary secretary of the Scottish branch.

Mr. P. R. Boulton, M.I.E.E., has retired from the position of Electrical Engineer (Distribution) in the department of the Chief Engineer, London Transport Executive, 55, Broadway, London, S.W.1, after 24 years' service.

Mr. E. W. Sanger is relinquishing his position as general sales manager of Birmingham Aluminium Casting (1903) Company, Limited, Birmid Works, Dartmouth-road, Smethwick, 40, Staffordshire, to take up the appointment of joint managing director of Begwaco Meters, Limited, Farnworth, Lancashire. Mr. Sanger will be succeeded by Mr. W. J. Price, formerly sales engineer of the "Birmal" organisation.

Mr. B. H. Dingley is leaving the overseas department of the Dunlop Rubber Company, Limited, at St. James's House, St. James's-street, London S.W.1, where he has been a senior assistant since 1945, to take up the position of manager of the firm's office in Batavia.

Among appointments made by the Council of Sheffield University on May 21 were those of Mr. R. Shepherd as lecturer in mining, Mr. P. A. H. Wyatt, as assistant lecturer in Chemistry, and Mr. J. Crangle as research demonstrator in physics.

Dr. F. Lloyd-Kessel, of G.P.U. Limited, has been appointed managing director of the recently-formed Cleanette Appliances Limited, which firm have a working agreement with H. Fisher (Oldham), Limited, in respect of production.

Lieut.-Comdr. C. H. Hayward, M.B.E., M.I.Mech.E., M.I.N.A., has been appointed by the Electroplant Company, Wembley, Middlesex, to be their supervisory engineer for Colombia, Ecuador, the Central American Republics, Mexico, the British and Dutch West Indies and several other Caribbean territories.

Mr. Charles Connell, managing director of Charles Connell and Company, Limited, Scotstoun, Glasgow, has been appointed to the board of the Iron Trades Employers' Insurance Association, Limited, and also to the board of the Association's subsidiary concern, Iron Trades Mutual Insurance Company, Limited.

Messrs. Dunlop Special Products, Limited, have removed their headquarters from Albany-street to 19-20, New Bond-street, London, W.1. (Telephone: MAYfair 9040; Telegrams: Dunspecial London.)

Conference on Liquid Fuels.—A joint conference is to be held under the auspices of the Institute of Petroleum and the Institute of Fuel at the University of Birmingham, from September 21 to 23. The provisional programme shows that the conference President, Mr. J. A. Oriel, C.B.E., will open the proceedings at 11.30 a.m. on September 21 with an address on "The Place of Liquid Fuel in the British Economy." The afternoon session will deal with "Fuel Oil in the Steel Industry," and the evening session with "Domestic Heating." On September 22, the morning session will deal with "Fuel Oil in the Metal Industries," and the afternoon session with "Fuel Oil in the Glass and Ceramic Industries." Two simultaneous morning sessions will be held on September 23, dealing, respectively, with "Gas Turbines" and with "Agricultural Drying Processes." In the afternoon, two further simultaneous sessions will be held, one on "Diesel Engines for Power Generation and Railway Traction," and the other on "Oil for Gas Making." The general secretary of the conference is Mr. R. W. Reynolds-Davies, 18, Devonshire-street, London, W.1.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel.—The industry is working at high pressure to reach the target set for it, and production continues at nearly record levels. The supply of scrap is adequate for current needs, but the margin in deliveries is almost negligible. Moreover, arrival cargoes of German scrap at Ardrossan and Grangemouth have been intermittent, and some misgivings are felt regarding the small additions to reserves for the winter when scrap collection at home will be more difficult. In a statement to shareholders of Messrs. Colvilles Limited, Sir John Craig, chairman of the company, has outlined extensions at the company's works entailing a large capital expenditure. Authority has been given for the erection of new coke-ovens at Clyde Iron Works to meet the needs of the three blast-furnaces there. Additional melting plant is also planned for Clydebridge, while extensive expansion of the plant at Dalzell and Lanarkshire is proposed.

Scottish Coal.—The new summer programme is being received favourably by consumers, who are becoming concerned more with the quality than with the quantity of their deliveries. Some of the Scottish steelworks are using 20 per cent. more fuel per ton of ingot output than they would have used if the sources of supply and the quality had been the same as in 1938, and but for substantial savings from the intensive utilisation of waste heat the rise in fuel cost per ton of steel would have been much greater. Deliveries to domestic users recently have been slightly below the allocation figure, but this has had no appreciable effect on the house-coal position owing to the reduction in demand. Electric power stations, gasworks, coke-ovens, and other priority users have been receiving their full prescribed tonnages. Shipments from East Coast ports included the usual tonnages for Sweden, Denmark and Finland, with an occasional cargo for Spain. There has been a steady rise in shipments from Scotland since the beginning of the year. The total having reached 106,028 tons in April, as compared with 41,796 tons in January. For the four months the tonnage shipped was 298,310, or, including bunker shipments, 602,003 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Welsh Coal Trade.—An interesting development in South Wales during the past week has been the installation of the first Diesel engine for underground haulage work. It develops 65 h.p. and has been lowered down the 1,000-ft. deep shaft at the North Pit, Llanharan. It weighs 10 tons and is the heaviest fitting ever lowered into the pit; a special cage had to be constructed to lower it. It will draw between 60 and 80 trams of coal at 10 m.p.h. along a track 1,000 ft. long with a gradient of 1 in 400. Work on the new roadway in the pit was begun last June and the coal seam was reached in February, thus establishing a record in British mining. During the seven months' work the heading was driven at a rate of 22 to 25 yards a week. Operations on the steam-coal market have not yet recovered fully from the dislocation caused by the Whitsun holiday interruption. The official holidays were one day for some of the pits and two days at others, but, as usual after a Bank Holiday, some absenteeism was experienced. As a result, operators were concentrating upon maintaining supplies already arranged, and little fresh business could be entertained for early delivery, particularly for export. There was considerable foreign inquiry, but trading generally was restricted to those countries with which a trade agreement had been concluded recently. There were some limited allocations for June delivery to Portugal, but, generally speaking, the release of coals is expected to remain slow until conditions have become normal. There was a steady demand for bunkers for supply at the local ports and patent fuel and cokes were also in keen request.

CALENDAR.—We have received a monthly tear-off wall calendar, current from April, 1948, to March, 1949, from Messrs. Metropolitan-Vickers Electrical Company, Limited, Trafford Park, Manchester, 17.

TEES-SIDE INDUSTRIES.—A booklet containing information on the industrial potentialities of Tees-side has recently been issued by the Tees-side Industrial Development Board, North Eastern Bank Chambers, Marton-road, Middlesbrough. Particulars of the constitution of the Board and of its objects are given and these are followed by information on the industrial facilities of the area and its railways and road communications, recreational facilities, shipping and docks, trading estates, and other matters of interest to manufacturers. A sketch-map of the region and views of Tees-side are included in the booklet, copies of which may be obtained from the secretary of the Board at the address given above.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—Iron and steel producing plants are operating at as high a level as conditions warrant, and are turning out tonnages on an unprecedented scale. Nevertheless, the total production falls considerably short of customers' requirements, both for home purposes and for shipment overseas, and every effort is being made still further to augment the make. A substantial improvement in the supplies of iron and steel scrap from home sources is reported, but imports from Germany are very disappointing and the total tonnage reaching the works is still much below requirements. An increase in the supply of blast-furnace coke would be appreciated and a considerable expansion in the yield of the Cleveland ironstone mines is required to cover users' demands. The present position necessitates extensive imports of foreign iron ores. The trade agreement with Spain opens up prospects of larger supplies of good quality ore from that country. The demand for maximum deliveries of pig iron and steel shows no reduction.

Foundry and Basic Iron.—North-East Coast users of foundry pig iron have had to draw supplies almost entirely from the Midland blast-furnaces, and while deliveries by rail from that area show some improvement, they are still inadequate for the consumers' current needs. There is no prospect of a resumption in the production of Cleveland ordinary foundry pig. The occasional temporary change-over of a basic blast-furnace to the production of iron for foundry purposes provides little of the tonnage needed for the manufacture of commodities required by home customers and buyers overseas. The whole of the basic iron output is promptly absorbed by the needs of the makers adjacent consuming works.

Hematite, Low-Phosphorus and Refined Iron.—East-Coast hematite manufacturers are barely able to cope with the requirements of their regular customers, all of whom are pressing for deliveries on a scale that would permit a movement towards the refilling of empty stock yards. The output of low-phosphorus grades of iron is being steadily consumed and there is no surplus make of refined iron.

Manufactured Iron and Steel.—Semi-finished and finished iron makers are busily employed and have substantial bookings, while steel producers, although achieving a record output, have difficulty in keeping pace with their delivery obligations. Reasonably good supplies of steel semies are reaching the re-rolling mills from the home manufacturers, but there is still acute scarcity of the much needed foreign products. The demand for all descriptions of finished steel is still intense, and producers cannot cope fully with customers' urgent needs. Shipbuilders are receiving large quantities of material, but are complaining that deliveries of essential supplies are limited.

Large Bridge for Tees-side Works.—Messrs. Dorman, Long and Company, Limited, are constructing for themselves a bridge which is part of a three-miles rail link between their Redcar and Cleveland works, across the new Lackenby site. It crosses the access corridor to the I.C.I. Wilton factory. The line will carry molten metal to the projected Lackenby steelworks in special cars, the loaded weight of which will be 175 tons, each ladle carrying 75 tons of metal. The bridge will be 360 ft. in length and will have five spans; it will contain 1,450 tons of steel. The line will be ready this year.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Production is in full swing following the holidays, during which repairs and overhauls of plant and machinery were undertaken. Steel outputs are tending higher again, but are still insufficient to meet the demand entirely. Some works making steel products are not able to secure all the steel they require. Manpower of the skilled type is in short supply. It has been necessary to design and construct an electrically-controlled press for producing springs for locomotives, carriages and wagons, which are needed in constantly increasing quantities. There are now only about 100 skilled spring fitters in Sheffield, compared with about 1,000 a few years ago.

South Yorkshire Coal Trade.—Supplies of coal are shorter following the holidays, and there has been some difficulty in meeting the requirements of industry and the export trade. Several vessels have been loading at the Humber ports and more arrivals are expected in the near future. The demand for coking coal is stronger, and coke works need larger supplies to enable the demands of the iron and steel trades to be satisfied, as well as to permit the sanctioned export of coke. Gas coal is in good request, but house coal is quiet. More opencast coal is being produced and allocated to most sections of the market.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS.—*South East London Branch:* Tuesday, June 1, 8 p.m., Castle Hotel, High-street, Eltham. Film: "On-Load Tap-Changing Transformers."

ROYAL SOCIETY OF ARTS.—Wednesday, June 2, 2.30 p.m., John Adam-street, W.C.2. Peter Le Neve Foster Lecture: "Craftsmanship—Summing Up," by Professor A. E. Richardson.

JUNIOR INSTITUTION OF ENGINEERS.—*Midland Section:* Wednesday, June 2, 6.30 p.m., James Watt Memorial Institute, Birmingham. "A New Approach to Band Conveyors," by Mr. O. J. B. Orwin.

INCORPORATED PLANT ENGINEERS.—*London Branch:* Wednesday, June 2, 7 p.m., The Royal Society of Arts, John Adam-street, W.C.2. "Plant in the Plastics Industry," Part II, by Mr. F. W. Parker. *Peterborough Branch:* Thursday, June 3, 7.30 p.m., Gas Company, Church-street, Peterborough. "Gas Manufacture," by Mr. F. A. Reid. *Birmingham Branch:* Friday, June 4, 7.30 p.m., Imperial Hotel, Birmingham. "Food Processing Plant and Its Maintenance," by Mr. L. D. North.

CHEMICAL SOCIETY.—Thursday, June 3, 7.30 p.m., Royal Institution, Albemarle-street, W.1. Liversidge Lecture: "The Modern Theory of Valency," by Professor L. C. Pauling.

INSTITUTION OF PRODUCTION ENGINEERS.—*Wolverhampton Graduate Section:* Tuesday, June 8, 7.15 p.m., Technical College, Walsall. Film: "Wheels Behind the Wheels."

CONTRACTS.

MESSRS. CHANCE BROTHERS, LIMITED, Smethwick, Staffordshire, have received a contract from the Crown Agents for the Colonies for the supply of three new lighthouses for Nigeria. Each will comprise a revolving light with clock, pedestal and 7 ft. 1 in.-diameter lantern. The illuminant employed in each light will be the firm's petroleum-vapour burner and each light will be mounted on a 120-ft. high fabricated-steel structure. Each double-flash light will have a candle-power of 38,000 and each triple-flash light a candle-power of 28,000. Chance Brothers are supplying all the equipment, including the steel towers.

MESSRS. THE BRITISH ROPEWAY ENGINEERING COMPANY, LIMITED, King William Street House, Arthur-street, London, E.C.4, have received an order for the supply of a bi-cable aerial ropeway for the New Zealand State Coal Mines, at Westport Stockton, on the west coast of South Island, New Zealand. The purpose of the ropeway, which is 5½ miles in length, is to bring 250 tons of coal an hour from three opencast sites to a main screening plant.

GUIDE TO CURRENT PRACTICE IN HEATING AND VENTILATING.—The Code of Practice Committee of the Institution of Heating and Ventilating Engineers are now engaged on revising the *I.H.V.E. Guide to Current Practice.* The Committee announce that it would be of assistance if members would inform the secretary of the Institution, 75, Eaton-place, London, S.W.1, of any errors they may have noticed in previous editions.

PATENTS, DESIGNS AND TRADE MARKS IN PAKISTAN.—The Government of Pakistan announce that a Patents and Designs Office and a Trade Marks Registry have been set up under the Indian Patents and Designs Act, 1911, and the Indian Trade Marks Act, 1940, as adapted for Pakistan. Persons wishing to patent their inventions or register their designs or trade marks in Pakistan, or who desire further information should communicate with the Controller of Patents and Designs and Registrar of Trade Marks, Ministry of Commerce, Industries and Works, Chief Court Buildings, Karachi.

COURSES IN GAS-TURBINE TECHNOLOGY.—The first of nine courses to be held this year at Great Britain's School of Gas Turbine Technology, Lutterworth, will commence on May 31, when technicians from various commercial organisations will attend for three weeks' instruction in the industrial uses of the gas turbine. In addition to engineers from the United Kingdom, Dominion representatives have enrolled for the course. The responsibility for the school and its syllabus rests with Power Jets (Research and Development), Limited, a company owned by the Ministry of Supply. Having learnt the basic theory of the gas turbine, those attending the course are shown practical testing procedure and instrumentation. Further particulars regarding subsequent courses may be obtained from the Ministry of Supply, Information Division, Room 206, Shell Mex House, Strand, London, W.C.2.

LAND-CLEARANCE EQUIPMENT FOR EAST AFRICA.

(*For Description, see Page* 513.)

FIG. 3. ROOT CUTTER IN TRAVELLING POSITION.

FIG. 4. STUMP REMOVER IN OPERATION.

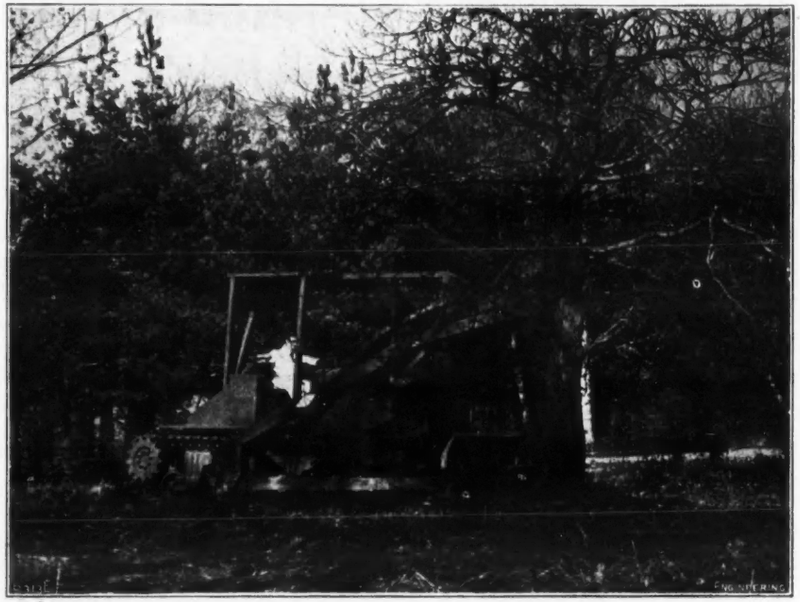


FIG. 5. TRACTOR AND TREE-FELLER IN OPERATION.

FIG. 6. TREE FELLING BEING COMPLETED BY STUMP REMOVER.

ENGINEERING.

35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

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ENGINEERING

FRIDAY, MAY 28, 1948.

VOL. 165. No. 4296.

WARSHIPS AND UNDER-WATER EXPLOSIONS.

SUBMARINE warfare would seem to have attracted the attention of men throughout the ages, since Alexander the Great went down in a glass vessel to observe the nature and customs of the fishes and thus learned how to lay ambushes against a foe by observing one army of fishes attack another, as a Twelfth-Century writer, Alexander Neckam, relates in his work *De Naturis Serum*. It appears that the Macedonian emperor remained submerged for some time, because he took with him a cock in order to learn by the bird's crowing the hour of dawn. Unfortunately, he failed to commit his observations to writing. Many centuries passed before electricity was applied to the explosion of under-water charges, by Sir Charles Pasley in the destruction of wrecks in the Thames and of the wreck of the Royal George at Spithead in 1839 and subsequent years, and the climax of development in this direction did not occur till the American Civil War, when several ships were sunk or damaged by mines or torpedoes. Subsequent perfection of the automobile torpedo and the submarine mine was due to a great extent to improvements in the manufacture and efficacy of explosives. Before the 1939-1945 war, the problem of damage to the machinery of a ship caused by shock from such explosions was not of major importance; previous war experience had not disclosed any weakness on this account when ships were hit by shells or torpedoes, though attention had been paid to the possibility of damage to condenser inlets and doors by the transmission of shock through the water. Some damage from blast had occurred when the guns of a ship were trained too close to the ship's structure.

The paper on "The Effect of Non-Contact Explosions on Warship Machinery Design," which Commander (E) A. D. Bonny, R.N., read before the Institution of Naval Architects on March 18, showed how very different were the problems of the recent war; our abridged reprint of Commander Bonny's paper is completed on another page of this issue. The damage done to H.M.S. Belfast in 1939 was followed by much more of a similar character and in most cases the machinery and electrical equipment suffered more heavily than the hull. By far the greatest part of the damage was caused by fracture of iron castings, though considerable subsidiary damage and derangement was brought about by the tripping of governors, defects in electrical breakers, lighting and other electrical equipment, gyro-compasses in particular being severely affected. All this differs in important particulars from the consequences of a direct hit by shell, bomb, or torpedo, as a result of which the devastation is localised near the point of impact, but little more than splinters may be expected outside the direct radius of the explosion. With the view to reducing the incidence of shock damage, the Admiralty Shock Committee was formed to examine the problem in the light of full-scale tests; it may be assumed, from recent Press references to preparations for further experiments, in which, apparently, the old battleship H.M.S. Nelson will be the target, that this Committee is still active.

The train of events following an underwater explosion is of great interest to the engineer as well as the naval architect. When the initial, or main, pulse strikes the hull of a ship, the shell plating, being relatively free, moves in the direction of propagation of the pressure with a very high acceleration, and attains a velocity of some tens of feet per second in a thousandth of a second, or less. The plating bends between the more rigid supporting frames, which, in turn, gain velocity by an amount that depends on the magnitude of the masses supported by them. As the stress wave arising from the pulse reaches the interior parts of the ship, they, in turn, are accelerated, and, after an interval of from 20 to 30 thousandths of a second, the whole ship is in this manner set into vibratory motion. At a given position on the structure, the pressure gradually dies away, and the elastic properties of the material together with damping agencies cause the structural components there to execute vibrations with a diminishing amplitude and, finally, to return to a position of rest. If the deflection is sufficiently large to produce plastic strain in the material, the plates will dish inwards, and this will be accompanied by distortion of the bulkheads in the case of considerable dishing. Thus the various parts of the ship are set in motion at different instants, the ship as a unit is deformed and, in addition to individual oscillations of plates and frames, larger structural components—for example, bulkheads—will tend to vibrate, and so the whole ship will oscillate as a beam with two or more nodes. This motion, referred to in the paper as "whipping," though involving considerably smaller accelerations than the initial shock, is associated with large displacements, up to 1 ft. or 2 ft.

No information is given as to the size of the vessels to which these deflections refer, though, presumably, they were destroyers, but, in this regard, they may not differ sensibly from the United States destroyers Preston and Bruce, the sagging tests and hogging tests of which were published in 1931 and 1940, in the *Transactions* of the American Society of Naval Architects and Marine Engineers. With the American destroyers, failure occurred at frame 87 in the sagging tests, and at frame 102½ in the hogging tests, under the action of bending moments which correspond to a deflection amidships of rather more than 1 ft. in the case of the Preston, and about three-quarters of that amount in the case of the Bruce. These figures, of course, relate to static conditions of stress, while those quoted by Commander Bonny relate to dynamic conditions; differences may have existed also between the loading of the four ships at the time of the tests. Even so, if the British destroyers were seaworthy after executing vibration of amplitudes within the range of 1 ft. and 2 ft. and in a mode involving two or more nodes, as seems possible in the absence of information to the contrary, it appears desirable to investigate further the maximum deflection which such ships can withstand under service conditions.

The transmission of the stress wave resulting from a pressure pulse is complicated by the occurrence of reflection at places on the structure distinguished by a sudden change in cross-section or in the physical properties of the material. The practical significance of this phenomenon in the matter of machine design is not so widely recognised as it should be; instances of it are to be found in most branches of engineering. In discussing this aspect of the subject, Commander Bonny remarked that "Even in the case of the shock wave experienced by light machinery items, the time of application of which is some two or three thousandths of a second, the effect of such wave propagations of stress does not show on records and can normally be neglected." The concluding part of this statement is not all that it might be; it resembles, indeed, a discussion of the behaviour of Hamlet which totally ignores the subject of his father's ghost. The effect of the propagation of such waves is clearly the damage to machinery and equipment, which is the essence of the matter. Again, the phenomena attending this propagation cannot be neglected without serious loss of available information, since the failure of components made of brittle material, which Commander Bonny illustrated by photographic reproductions, can be explained in terms of these phenomena. It is not to be expected that the profile of an individual stress-wave would show on records taken inside a ship, for what is actually recorded there is the resultant of numerous internal reflections, as may often be inferred from the relatively wide trace of records taken inside the ship. In work of this character, it is of practical importance to realise that the record of such a profile can be obtained, strictly speaking, only on the surface of the plating nearest to the source of the disturbance in the case of a non-contact explosion.

Useful design data for accelerations to be worked to are given in the paper, the values for the average auxiliary being 120 times the acceleration of gravity for the upward direction, and from 40 to 60 times the same unit athwartship, with an intermediate value for the downward direction. Thus, an auxiliary machine designed for these figures should be capable of withstanding a load equal to, but not exceeding, 120 times its own weight applied to its base in the upward direction for an indefinite period of time. While it is always desirable to express a design specification in the simplest possible terms, it is hardly ever profitable to secure this simplicity at the expense of generality, as seems to have occurred here in basing the specification on acceleration alone. On this basis, the figure demanded for the barbette, the turret, or the guns of a big ship would, of necessity, be much less than the figure mentioned above for auxiliary equipment, and yet such equipment must be placed on the barbette or the turret. Serious damage to the fire control, for example, would not necessarily put the guns out of action, but the accuracy and value of gunfire would be entirely destroyed through the destruction of the fire-control equipment. Experience seems to show that too much reliance has sometimes been placed even on flexible mountings, which may have been designed with reference only to acceleration.

Although there is much to learn yet about the forces brought into play by a non-contact explosion, Commander Bonny's paper affords means of arriving at reasonable approximations as to their magnitude and duration. This information, coupled with a knowledge of the principles of mechanics, should enable the engineer to produce machinery that will withstand these forces and in this way to obviate the major casualties which have hitherto occurred, due to this cause. The present trend is towards the substitution of ductile for brittle materials, and the improvement of resilient mountings as regards maintenance and adaptability; in all this, there is much scope for those interested in naval engineering. It may be, of course, that the need to disperse ships and dockyard facilities, as a counter to possible atom-bomb attack, may have the incidental result of diminishing the risk of mine damage such as Commander Bonny was discussing, since the mine is normally a shallow-water weapon and future fleets may have to rely more on repair ships than on dockyards.

CLEAN AND DIRTY RIVERS.

THE title of this article is borrowed, without permission, from a recent lecture delivered by Dr. B. A. Southgate, Director of Water Pollution Research, to the Hertfordshire Natural History Society. It is appropriate that Dr. Southgate's name should appear in connection with this subject, as in a recent book* dealing with it, the Water Pollution Research Board is referred to as the "really bright spark" in an "otherwise dark outlook for our rivers." This statement verges on exaggeration, as the Board has no administrative authority in connection with river pollution and, in any case, the author does not appear to have kept closely in touch with its work, as its most recent report referred to is that for the year 1937, and Dr. A. Parker is described as Assistant Director of Water Pollution Research; Dr. Parker has been Director of the Fuel Research Station since 1943. It is stated on the jacket that Mr. Kempster died while the book was going through the Press, and in one place he, himself, states that he started to write it more than ten years ago. These circumstances may help to explain its remoteness from the present activities of the Board.

Although methods for the treatment of sewage and trade wastes which have been worked out by the staff of the Water Pollution Research Board have done much, and in future will do more, to reduce river pollution, the work of the "bright spark" is not really the subject of this book; the achievement of the ends which the author had so much at heart depend more on the administrative activities of a large number of public bodies, than on technical advances made by any scientific authority. The major part of the book is made up of an interesting detailed account of his legislative and administrative aspects of the complicated and difficult subject of river control, from the first English statutes of the reign of Henry III, which concerned weirs in the Thames and Medway and the 1285 Act in the reign of Edward I prescribing annual close seasons for salmon in various English rivers, down to the activities of the Central Advisory Water Committee which was set up in 1937. In its third report this committee recommended the setting up of river boards which would take over and co-ordinate the duties of various existing bodies which, in many cases, have neither the funds nor the authority to perform the tasks with which they are charged. There is a pathetic aspect in the fact that the author did not live to see the River Boards Bill, which was presented to Parliament last November, and which may ultimately lead to the condition for which he pleads.

A considerable amount of attention is given in this book to serious effects of pollution on river and estuary fishing but the author recognises that the activities of anglers, although to many of them the most important things in life, are a relatively minor matter in the general economy of the country. Questions of land drainage, water supply and the disposal of trade effluents are important factors in the general subject of river administration and control. Nevertheless, freshwater fish might make a considerably larger contribution to the nation's food supply than they do at present. In their natural state, the rivers of Great Britain are among the best in the world for salmon and sea trout, and possible supplies of coarser, but usable, fish are considerable. Salmon and trout, by far the most attractive and useful, have forsaken many rivers in which they were once common. In 1884, 1885 and 1887, the salmon taken by net in the River Trent numbered 2,700, 3,050 and 3,120, respectively; in 1936, 1937 and 1938, they numbered 80, 100 and 35. Viewed on a purely financial basis, river purification for the sole purpose of fish cultivation would probably not be a paying proposition, but the commercial value of the fish harvest should not be overlooked.

Some rivers are nothing more than open sewers and are not only an offence to the eye and nose but probably have an unfavourable effect on public health. At a time when so much is talked of amenities, it might have been expected that more protest would have been raised about rivers carrying filth that would not be tolerated on a public highway. The basis of the trouble is that a river may pass through the areas of a number of different authorities none of whom are officially concerned with it outside their own boundaries. A small town may turn an unsatisfactory sewage effluent into a river, possibly because it is not in a position to install an expensive treatment plant, and other towns farther down the river will suffer. The activity of the small town will probably be innocuous officially as there is no statutory standard of impurity for sewage effluent; or a large factory may pollute a river with some form of trade waste and there may be no body with the authority to prevent it.

In general, the only bodies which have been concerned with rivers as a whole are the Fishery Boards. These, in England and Wales, derive their main income from fishing licences which, in the aggregate, represent a comparatively small sum, although a few obtain additional income from proceeds of rating assessments, payments in lieu of compensation water, and other miscellaneous sources. Theoretically, a fishery board can charge a sanitary authority with polluting a river, but it is necessary to prove that a particular discharge is injuring the fish, which may well be impossible; and in a river which has been polluted for years there will be no fish to injure so that this procedure, even when a board can afford to undertake it, is ineffective. In the cases of four rivers, authorities with more power and larger funds are in existence. These have set up under the Local Government Act, 1888, which permits the constitution of joint authorities representing the different counties through which a river or its tributaries pass. The four authorities are the West Riding Rivers Board, the Mersey and Irwell Joint Committee, the Ribble Joint Committee, and the River Dee Joint Committee. These bodies have done excellent work, but clearly are far from covering the whole country.

The new River Boards Bill, which has already passed through all its stages in the House of Commons, proposes the setting up of boards for "the whole of England and Wales," except the Thames and Lee catchment areas. Functions concerning land drainage, fisheries and river pollution now exercised by "catchment boards, fishery boards and certain joint boards and joint committees of local authorities" would be transferred to the new bodies. The river board areas will be determined by the Minister of Agriculture and Fisheries in conjunction with the Minister of Health; and the boards will consist of representatives of the councils of local authorities concerned and of fishing and land-drainage interests.

The omission of the Thames and Lee catchment areas from this scheme is a matter of interest. It is an expression of the fact that these districts are already administered in a highly satisfactory manner. The anti-pollution activities of the Thames and Lee Conservancy Boards are already considerable. The Thames catchment area covers 3,812 sq. miles and lies in fourteen different counties, but control is so effective that the Metropolitan Water Board is able to extract 60 per cent. of its annual supply of domestic water from the river, and it is stated that the Thames above Teddington Weir is one of the purest rivers in the country. The lower tidal portion, however, which is not under the jurisdiction of the Conservancy, is seriously polluted; only one salmon is known to have been caught in the Thames in the last forty years and that had evidently lost its way. The quality of the sewage discharged to the Thames has been greatly improved by the construction of the Mogden sewage works, which serve a population of 1,250,000 people and produce an effluent of very high quality. It is not clear that the new river boards will have power to father unification schemes of the Mogden type, which by eliminating a number of small independent sewage works, enable extensive purification plant to be installed, but as the boards will represent the local authorities concerned with the whole course of a river system, it is probable that greater co-operation may be introduced than has been general in the past.

* *Our Rivers*, by J. W. Kempster. Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4. [Price 25s. net.]

NOTES.

THE TELECOMMUNICATIONS RESEARCH ESTABLISHMENT.

THE Minister of Supply, Mr. G. R. Strauss, on May 25, opened at the Telecommunications Research Establishment, Great Malvern, an exhibition —which closes to-day—to indicate the nature of the work carried out at the Establishment, and to encourage industrialists and others to make full use of the facilities it offers. "T.R.E." began with a staff of six in 1935 and is part of the Research and Development Branch of the Ministry of Supply. It conducts research and development in radio and electronics for the Royal Air Force and the Fleet Air Arm, as well as for the Ministry of Civil Aviation and the Department of Scientific and Industrial Research. During the war years, when its staff grew to several thousand, it was mainly responsible for researches leading to the development of radar equipment for the fighting Services; the present staff totals over 2,000, among whom are some 300 qualified technicians and scientific officers. The Establishment is divided into three major departments: radar, physics and engineering. The engineering group has main workshops and drawing offices covering some 72,000 sq. ft. and is responsible for the design and construction of equipment to the requirements of the scientific staff. Its auxiliary services include spraying, plating, heat-treatment, welding, and patternmaking shops, as well as a small section for the manufacture of radio-type transformers. The physics department contains a theoretical-physics group, and a section concerned with the development of high-energy particle accelerators for atomic energy and medical research. Investigations are also carried out on the properties of very short radio waves, on infra-red radiation, and on the application of radar techniques to problems in meteorology. This department is also responsible for fundamental measurements and for the maintenance of the Establishment's substandard instruments. The radar section is concerned mainly with the development of radio and navigational aids and with the application of radar to the problems of aerial attack and defence. Several exhibits and demonstrations show the uses to which radar had been, and was being, put, of which methods of aerial photography for survey and mapmaking purposes deserves special mention. Altogether, there are some 50 major exhibits. Among those which may be considered of most general interest and, perhaps, of immediate application, are various types of servo- and remote-control mechanisms, a magnetic amplifier capable of detecting signals of 10^{-17} watts at frequencies below 10 cycles per second, and apparatus for testing equipment under conditions of vibration, or when subjected to environments simulating tropical and arctic conditions. Simple forms of light-weight container and packaging equipment are also shown. Other exhibits include an automatic recording spectro-photometer which was developed in conjunction with the Medical Research Council for speeding up the analysis of compounds in solution, together with various instruments for measuring the strength of radioactive fields. A working model was also shown of an automatic following telescope, actuated electronically by the light of the heavenly body or star upon which it was focused. During the speeches of the Minister of Supply and the chief superintendent it was stated that, apart from certain security considerations, the equipment developed in the Establishment is now being made known to industry as a whole. It is hoped that firms and other interested bodies will co-operate to find further uses for this equipment; such co-operation will undoubtedly help the country to recoup some of the expenditure incurred on wartime research. The chief superintendent of T.R.E. is Mr. W. J. Richards, B.Sc.

ELECTRICITY SUPPLY BREAKDOWNS IN SOUTHERN ENGLAND.

Two serious breakdowns in the supply of electricity in the eastern, south-eastern and western districts of England, including London, occurred on Sunday, May 23. The first of these affected an area extending from Norwich to Eastbourne and lasted from 12.25 p.m. to 2.30 p.m. in the majority of places, although in others the supply was not fully restored until an hour later. In the evening the area affected lay south-east of a line between Norwich and the Bristol Channel, supplies being cut off at 8.54 p.m. and being gradually restored between 9.30 and 10.40 p.m. The cause of these breakdowns was three-fold. At this time of year it is necessary to have a large amount of plant, especially boilers, out of action for routine maintenance, while on Sundays, in addition, the opportunity is taken to deal with short-time repairs. As a result, on Sunday, of the 10,943 MW of plant installed no less than 4,383 MW was not available. In organising the detailed maintenance programmes use is made of long-time weather forecasts to estimate the load and these are supplemented by the shorter-time Air Ministry reports. On Friday it was forecast that the midday temperature on Sunday would be 59 deg. F., while at 6 a.m. on Sunday it was estimated that it would be 57 deg. F. The actual temperature, however, was 48·5 deg. F., in addition to which the weather was rainy and overcast. On the basis of the forecasts it was estimated that the midday load in south-east and eastern England, including London, would be 1,800 MW, to meet which it had been arranged that 90 MW should be imported from north and central England over two lines. Owing to the weather, however, the imports actually reached 190 MW, a large part of which was being transmitted over the King's Lynn-Norwich line to meet a total load of nearly 2,000 MW. As a result of this overloading, a fault occurred at a through-joint on this line, causing a breakage of the conductor. The load was therefore thrown on to three other circuits, the switches on which opened, leaving the southern area isolated from the rest of the grid. The generating plant in the isolated area being insufficient to meet the demand, had generally to be shut down to avoid dangerous overload, although some local systems were able to maintain a supply. Load shedding could not, of course, be effected at such short notice. In the evening, with the Kings Lynn-Norwich line still out of action, it was decided to bring in a line between Bedford and Luton, which had been under repair. This, however, also failed as the load came on, with the result that the network was split up into a number of isolated sections, in some of which load shedding was effected up to 25 per cent. It is only fair to the Central Electricity Board and the British Electricity Authority to add that such breakdowns are rare, the last of comparable magnitude having also occurred on a Sunday in the summer of 1934. The principal remedy is, of course, the provision of sufficient generating plant, a task which has been rendered difficult by the policies of both the late and the present Governments, as is shown by the fact that next winter there will be a plant deficiency of some 1,800 MW. On the other hand, there is every reason to suppose that the transmission system is being adequately maintained, while the protective gear is undergoing constant improvement.

SHELL LABORATORIES AT THORNTON.

What are probably the finest laboratories in this country for research on fuels and lubricants are situated at Thornton-le-Moors, near Chester, close to the large Shell refinery at Stanlow. When we described the work being undertaken there last year, on page 355 of our 163rd volume, control of the research centre had recently reverted from the Ministry of Supply to the Shell group of companies. Last Thursday, May 20, the Shell Refining and Marketing Company, Limited, invited a large number of guests, including representatives of the Services, engineering firms and the Press, to visit Thornton and witness the formal opening, by Mr. George Legh-Jones, managing director, of a new laboratory for research on Diesel fuels and allied subjects. The Diesel-fuel laboratory, as it is called, is housed in two single-storey buildings near the original laboratory; one is U-shaped in plan, and the other is T-shaped, and there is room for extensions, if required. Many problems are now being investigated, and in the course of a rapid tour we were shown some of this work. In one room, cetane rating tests were being undertaken, using a constant-ignition-delay engine with a variable compression ratio. In other rooms, the formation of fuel sprays could be examined by stroboscopic means, and the fouling of injector nozzles was being investigated in a special "hot nozzle rig." As noted last year, in connection with petrol engines, many tests are conducted with the object of assessing the factors relating to cylinder wear and fouling of pistons. In most cases, single-cylinder engines are used for this purpose. Several engines had been arranged for "pilot" injection (in which a small quantity of fuel is injected in advance of the main quantity), and cathode-ray tubes had been connected to show the increase in the pressure acting on the piston and the reduction of vibration in relation to the pilot injection, which could be introduced and eliminated while the engine was running. A large two-stroke engine was being run successfully on very heavy oil, and two engine cells had been set aside for carrying out tests on engines on behalf of the manufacturers. A new cold room provides temperatures down to — 60 deg. C. for engine tests, which is 20 deg. lower than could be obtained in the older cold room. The guests were also conducted round the original laboratories, and were shown the useful applications of secondary petroleum products in the manufacture of rubber and plastics, and the beneficial effect on the useful life of transformer oil due to the addition of an anti-oxidant. Lieut.-General J. H. Doolittle, K.C.M.G., director of the Shell Union Oil Corporation, New York, said at the opening ceremony that, during the war, he was at one time or another short of pilots, mechanics, aeroplanes, bombs and ammunition, but never of fuel. Admiral of the Fleet Sir John D. Cunningham, G.C.B., on behalf of his fellow guests, thanked the company, for the facilities afforded of seeing the work.

THE INSTITUTE OF PHYSICS.

The new President of the Institute of Physics, for the 1948-49 session, is Dr. F. C. Toy, director of research, the British Cotton Industry Research Association. He was elected to succeed Professor A. M. Tyndall, F.R.S., at the annual general meeting of the Institute, held on May 20. Other elections included those of Dr. T. E. Allibone as a vice-president and of Mr. J. H. Awbery and Mr. E. W. H. Selwyn as ordinary members of the board. Mr. E. R. Davies, O.B.E., was re-elected honorary treasurer and Dr. B. P. Dudding, M.B.E., honorary secretary. The twenty-eighth annual report of the board covering the work of the Institute for 1947 was presented at the meeting; it indicates that the membership continues to grow at a little over 10 per cent. per annum, and was 3,268 on December 31, 1947, as compared with 2,906 at the end of 1946. Although progress in the repairs and improvements to the Institute's new headquarters at 47, Belgrave-square, London, S.W.1, has been slow, owing to the prevailing conditions, considerable benefit was derived from the increased accommodation and facilities afforded during 1947, the first year of occupation of the premises. Among other new Institute publications in hand are a book containing a selection from the "Laboratory and Workshop Notes" which have appeared in the *Journal of Scientific Instruments*; a report in book form of the papers read at the conference on "The Measurement of Stress and Strain" held in Manchester in July, 1946; and a second edition of the *Handbook of Industrial Radiology*, edited by Professor J. A. Crowther. Increased interest in the newly-established National Certificates in Applied Physics has been shown by colleges and by prospective students. An illustrated booklet, entitled "Experimental Science—A Career for the Practical Boy or Girl," has been produced and widely distributed. As recorded in our columns at the time, the Institute, with the Physical Society and in collaboration with the Institution of Electrical Engineers, organised celebrations to mark the jubilee of the discovery of the electron by J. J. Thomson. These included a series of lectures and a special exhibition in the Science Museum, South Kensington. The Institute has seven branches in industrial districts at home and in Australia and India, and six subject groups covering, respectively, electronics, industrial radiology, X-ray analysis, industrial spectroscopy, electron microscopy, and stress analysis. The last-mentioned group is the newest, having been formed in March, 1947. All held many meetings during the

year and as these are open to others than physicists, many engineers, chemists, metallurgists and other scientific men have taken advantage of the facilities offered. The meetings, it is pointed out, are the principal instrument by which the board of the Institute implement their policy of demonstrating how the application of physics can assist industrialists.

THE INSTITUTION OF ENGINEERS IN CHARGE.

The 43rd annual dinner of the Institution of Engineers in Charge was held at the Holborn Restaurant, London, W.C.2, on Friday, May 21. In the absence through illness of the President (Lieut.-Colonel J. D. K. Restler, O.B.E.), the chair was taken by Mr. Robert Chalmers, O.B.E., vice-president. The toast of "Our Democratic Institutions" was proposed by Sir Charles Bressey, C.B., C.B.E., who took a somewhat wider interpretation of the phrase than that of engineering institutions only; bearing in mind, no doubt, that the response was to be by Sir John Wardlaw-Milne, K.B.E., he extended his subject to include also all those social and legislative institutions of the country which are commonly comprised in the term "the British way of life," observing that their most characteristic feature was an extraordinary tolerance. Sir John followed the same general line in his reply, but commented that, too often, people spoke of "democratic institutions" without having any clear idea of what they meant. Mr. A. Robertson, M.I.N.A., honorary treasurer of the Institute of Marine Engineers, deputised for Sir Robert Micklem, the President of that Institute, in proposing the toast of "The Institution," remarking in so doing upon the fact that Captain A. E. Penn had been its secretary for 36 out of its 43 years of existence. He noted that a large proportion of its founder members had been marine engineers, and expressed the wish, which those present endorsed by applause, that the old standards of engineering apprenticeship could be restored. Mr. Chalmers, in acknowledging the toast, did not venture upon this permanently controversial topic, but showed, by a review of recent activities, that the Institution maintained its initial practical outlook. He then proposed the toast of "Our Guests and Friends," taking the opportunity to express the regret of the members at the recent death of Sir William Reavell, a past-president and an active supporter of the Institution over many years. Mr. L. Copeland Watts, President of the Institution of Heating and Ventilating Engineers, responded on behalf of the guests.

INTERNATIONAL MECHANICAL ENGINEERING CONGRESS.

A congress to discuss the practical problems of mechanical engineering production, as distinct from theoretical considerations, is to be held in Paris from September 13 to 18, inclusive. The programme has been drawn up with two main objects in view: firstly, to survey the most recent information on new methods and techniques of metal-working and, secondly, to consider how recent developments in manufacturing technique affect basic design. British contributions will relate to the subjects of powder metallurgy, the use of non-ferrous alloys for castings exposed to stress, grinding wheels, diamond tools, and the removal of rust. Papers to be submitted from other countries will include mass-production techniques, non-metallic bearings, surface broaching, and the testing of materials, from the United States; machine-tool construction, plastics, welded construction, and gas-cutting, from France; lubrication, high-frequency induction heating, and centreless grinding, from Sweden; heavy forgings from Czechoslovakia; the relation between precision and cost in manufacture, and feed arrangements for machine tools, from Switzerland, etc. Particulars may be obtained from the Publications Division of the British Engineers' Association, 32, Victoria-street, London, S.W.1; or direct from the Sécrétariat Général du Congrès International des Fabrications Mécaniques, 11. Avenue Hoche, Paris, VIIIe, France. Various visits to works, etc., have been arranged in connection with the Congress, and those participants who wish to do so will be able to proceed from it to the French Machine-Tool and Engineering Exhibition at Basle, which opens on September 18 and continues until September 25.

LETTER TO THE EDITOR.

THE ADMINISTRATION OF PORTS.

TO THE EDITOR OF ENGINEERING.

SIR,—My attention has been drawn to an article on the Administration of Ports, which appears on page 422 of your issue of April 30, towards the end of which it is stated that the turn-round at the Port of Beira takes 90 days. While it is true that there was considerable congestion at the Port earlier this year, this has now been overcome and, in fact, I have only this week received the following reply from our General Manager to a cable which I sent. "No delays to shipping in May to date, but one or two ships may be delayed one or two days between 22nd and end of month owing to bunching of arrivals." In view of the exaggerated statement of your correspondent, which was never true even of the worst period of congestion, I should be glad if you would print in an early issue the substance of the cable which I have quoted.

Yours faithfully,
E. D. HAWKSLEY,
Assistant Secretary.

Beira Works, Limited,
11, Old Jewry, London, E.C.2.
May 21, 1948.

[The article referred to was based on a paper entitled "The Future of British Ports and Canals," read before the Institute of Transport on April 12 by Mr. W. A. Flere, and the statement about which Mr. Hawksley complains appears in that paper.—ED. E.]

OBITUARY.

PROFESSOR W. T. DAVID.

IT is with much regret that we have learned of the sudden death on May 22, at the age of 62, of Professor W. T. David, who had occupied for some 26 years the chair of engineering in the University of Leeds. He will be remembered particularly for his studies of the properties of the working fluid in internal-combustion engines, and especially in gas engines, on which subject he contributed several articles to our columns.

William Thomas David was a native of Laugharne, Carmarthenshire, where he was born on April 19, 1886. On leaving the County School at St. David's, he went to University College, Cardiff, where he obtained the degree of B.Sc. (Engineering). He then entered the works of Messrs. Mather and Platt, Limited, Manchester, for two years' practical training and, in 1908, went to Trinity College, Cambridge, where he was engaged on post-graduate research on the working fluid of internal-combustion engines, under Professor Bertram Hopkinson, which was recognised by the award of a B.A. degree. He returned to Manchester in 1911 as assistant gas-engine designer to Messrs. Mather and Platt, but in the following year was appointed an Inspector of Technical Colleges under the Board of Education. In 1915, he was seconded to Woolwich Arsenal for inspection duties on guns and ammunition, with the rank of major; and two years later was transferred to the Ministry of Munitions, in charge of the dilution of labour, especially in shipyards. At the end of the war, he returned for a short time to the Board of Education, but in 1920 was appointed Professor of Engineering at University College, Cardiff. His tenure of this chair was brief, for in 1922 he was appointed Professor of Civil and Mechanical Engineering at Leeds, where the rest of his life was spent. Professor David held the degrees of M.A. and Sc.D. of the University of Cambridge and the D.Sc. (Wales). He contributed various papers to the Institution of Mechanical Engineers, and was a recipient of a Thomas Hawksley Gold Medal, the Starley Premium and a Dugald Clerk Prize.

H.M. AIRCRAFT CARRIER "VENERABLE."—The light fleet carrier H.M.S. Venerable, which is to be transferred to the Royal Netherlands Navy, will be handed over to her Dutch crew at Plymouth to-day, May 28. She will be renamed Karel Doorman.

THE ROYAL SOCIETY CONVERSAZIONE.

THE annual conversazione of the Royal Society was held at Burlington House, London, W.1, on Thursday, May 20, the Fellows and guests being received by the President, Sir Robert Robinson. As usual, numerous scientific exhibits were on view, and these, we are informed are intended "to further the objects of the Royal Society of London for Improving Natural Knowledge by creating an interest in scientific research." This laudable object was assisted on this occasion by admitting a number of schoolchildren to see the exhibits on the morning after the conversazione itself.

The historical exhibits, which are always a feature of the gathering, included, on this occasion, the Mace of the Society, which was presented by King Charles II in 1663, and the Charter Book, which contains the signatures of the Royal Patrons and Fellows. An original manuscript of Heinrich Rudolf Hertz relating to the researches which subsequently laid the foundations of radio communication was also on view. This manuscript, which is dated 1888, was presented ten years ago to the Science Museum by Hertz's widow and describes the method of producing electromagnetic waves, their propagation, polarisation, reflection and refraction. The experiments, of which details are given, confirm the identity of electromagnetic waves with light and radiant heat. It was published in *Sitzungberichte der Akademie der Wissenschaften zu Berlin*, under the title of "Uber Strahlen der elektrischer Kraft."

The measurement of the power of small radio-frequency noises was illustrated by the Cavendish Laboratory, Cambridge, on apparatus which has been developed in connection with the observation of radio-frequency radiation from the sun and stars. This measures and records automatically noise powers of the order of 10^{-16} watts, which is about 1 per cent. of the noise inherent in the receiving amplifier. For reasons of stability and accuracy, the receiver is used only to indicate equality between the powers of the incoming noise and of a local source. A wave form characteristic of the misalignment between the two powers is then produced in the receiver output and is employed to adjust the local source of a noise towards equality. A rapid response to sudden input changes is obtained by the employment of feedback through a non-linear resistance. An output relatively free from fluctuations under conditions of steady input is obtained in the same way.

A demonstration of length measurement by interferometry was given by the Metrology Division of the National Physical Laboratory, Teddington. In this, the length of engineer's block gauges up to 300 mm. (12 in.) was measured directly with a Kosters gauge interferometer. This German instrument is an adaptation of the Twyman and Green modification of the Michelson interferometer, a hot-cathode krypton lamp cooled by liquid air being used as a source of standard wavelengths. Seven wavelengths are employed in the range between 4,502 and 6,456 Å., and it is stated that an accuracy of about 0·025 μ (1×10^{-6} in.) can be obtained on 12-in. gauges, provided precautions are taken to control and measure the gauge and atmospheric temperatures, as well as the pressure and composition. A thermocouple is used in association with a standard mercury thermometer to measure the gauge temperature. The thermal expansion coefficients of the gauges are determined at 20 deg. C. to $\pm \frac{1}{2}$ per cent. over a range of only 1 deg. C.

Among the exhibits of private firms special mention may be made of the laboratory apparatus for figuring an optical surface by the controlled deposition of aluminium in a vacuum, which was demonstrated by Messrs. Grubb, Parsons and Company, Walker Gate, Newcastle-on-Tyne, 6. This has been designed to reduce the labour of working a glass mirror to a final parabolic form of great accuracy. It includes a heater with a tungsten-wire element to which small globules of aluminium are attached. Above this heater an appropriately shaped mask is arranged to graduate the exposure of the mirror face to the aluminium particles. The mirrors are dealt with in groups of five, and are

mounted on a rotating table, above the heater and mask, which is driven by a clock spring restrained by a fuse wire. The whole assembly is placed in a vacuum chamber and a current of 100 amperes is passed through the heating element, so that the aluminium melts and evaporates. After an interval, the fuse wire also melts, thus releasing the spring and causing the table to rotate. This rotation continues freely for several minutes, during which time successive depositions can be applied.

The British Thomson-Houston Company, Limited, Rugby, were showing a full-scale model of the betatron, which has been installed recently in the Clarendon Laboratory, Oxford. This instrument is essentially an electron accelerator, the electrons themselves being injected into an increasing radially symmetrical magnetic field, which is arranged to maintain them in a stable circular orbit during the acceleration period. They execute many turns in this orbit and in doing so pick up energy continuously by induction from the magnetic field. The particular betatron, of which the model was shown, weighs 17 cwt. and accelerates the electrons to 16·3 million electron volts, the 50-cycle input being 80 kVA. The weight and input are lower than customary and these reductions have been rendered possible by using a narrow orbit space and a closed central leg, so that the only major flux in air is the annular guide field. The accelerating and guide fluxes are produced by two co-axial windings, which lie radially on either side of the orbit. These windings are excited in parallel, so that the accelerating flux, most of which is in the closed central leg, bears the necessary relation to the guide flux. In other words, the betatron resembles a transformer with a loaded inner secondary winding, the core flux of which corresponds to the accelerating flux, while the leakage flux provides the guide field. The accelerated electrons circulate more than a million times in an exhausted glass ring, the pressure in which is kept below 10^{-5} mm. of mercury, and travel over 900 miles in doing so. By pulse-exciting an appropriate winding at the desired instant, the relation between the guide and accelerating fluxes can be altered so that the high-velocity electrons—beta rays—are converted into high-intensity gamma radiation.

The same firm were exhibiting specimens of the new glasses that have been developed to enable glass, metal and mica to be "soldered" to glass. Such a glass must have a coefficient of expansion comparable with that of the articles to be soldered and a suitable viscosity/temperature relationship. It must also flow at from 500 deg. to 600 deg. C. and be durable. It has been found that a lead and barium borate glass is satisfactory for this purpose, except on the score of durability. A zinc-borate glass is an improvement in this respect, while that containing a small proportion of silica is even better.

Imperial Chemical Industries, Limited (Explosives Division), 25, Bothwell-street, Glasgow, C.2, were exhibiting an "electronic stop watch" for controlling the operation of detonators designed to explode in 10 seconds to within 0·01 second. This consists essentially of a standard oscillator which supplies a specially designed pair of split-phase motors with polarised direct-current. The two phases of both motors are directly coupled to two inverters, which are operated in quadrature. The motors are thus continuously energised in a direction depending on which side of their respective inverter is conducting. As a result, the armature is locked in one of four positions or moves discontinuously between them as the inverters alternately commutate the current in the two field coils.

The Cambridge Instrument Company, Limited, 13, Grosvenor-place, London, S.W.1, showed an oxygen recorder which depends on the change of paramagnetism of the gas with temperature. A reference to this was made in our account of the Physical Society's Exhibition on page 367, *ante*. During the evening a sound film entitled "Mitosis of Living Cells and Tissue Culture shown by Phase-Contrast" was exhibited by Messrs. Cooke, Troughton and Sims, Limited, Broadway-court, London, S.W.1. This film was prepared by Dr. Hughes, of the Strangeways Laboratory, using Cooke phase-contrast equipment, and shows living cells both in the resting stage and in process of dividing.

THE IRON AND STEEL INSTITUTE.

(Concluded from page 498.)

We conclude below our report of the annual general meeting of the Iron and Steel Institute, held in London, on May 5 and 6.

Steel Ingots and Ingot Moulds.

The last joint discussion held at the meeting was on the subject of three papers dealing with various aspects of ingot moulds and steel ingots. The first paper was entitled "A Comparison of Moulds of Standard Composition," and was by Mr. W. L. Kerlie, of Messrs. Stewarts and Lloyds, Limited, Corby. The author stated that his experiments had been designed primarily to compare the lives of moulds of works standard composition and a composition suggested by the Ingot Moulds Sub-Committee (I.M.S.C.), the latter having total carbon approaching 4 per cent., silicon 1 to 1·25 per cent., sulphur approximately 0·06 per cent., phosphorus approximately 0·25 per cent., and manganese 0·8 to 1·0 per cent. The moulds investigated were all of the corrugated type, having a 25-in. square bottom and a 22⅝ in. square top, and a weight of 4·2 tons. The weight of the basic-Bessemer rimming steel ingots produced ranged from 4 to 4¼ tons. The conclusions arrived at were that the mould life increased with decreasing silicon content, the average mould life was above 100 ingots when the silicon content was below 1·5 per cent. With a mould composition close to the I.M.S.C. recommended composition (from 1·0 to 1·2 per cent. of silicon), an average mould life of 130 ingots was to be expected, compared with an average of 100 for the standard composition (1·45 per cent. of silicon). The difference in the phosphorus content between the two compositions (the average difference was 0·12 per cent.) might well be the cause of the small improvement in mould life of 8 ingots in favour of the I.M.S.C. composition. The data, when examined as a whole, showed that increases in the phosphorus content to at least 0·15 per cent. increased the expected life of moulds.

In the second paper, "Mould-Weight/Ingot-Weight Ratio and its Relation to Mould Composition," Mr. N. H. Bacon, of the United Steel Companies, Limited, Sheffield, stated that an examination had been made of the very comprehensive data provided by three Ingot Moulds Sub-Committee questionnaires (one pre-war and two post-war), and British Intelligence Objectives Sub-Committee final report No. 685, on "German Ingot Moulds for the Casting of Steel Ingots." Very large variations in mould-weight/ingot-weight ratio had been found; in the United Kingdom the ratio ranged from 0·78 to 1·76, and, in Germany, from 0·61 to 1·82. It appeared from the data that for moulds of capacities of more than 18 cwt. an optimum M/I ratio could be employed to calculate wall thickness. The M/I ratio was the ratio of the weight of the mould to that of the ingot for which it was used. Thus, for round, octagon, or nearly square moulds,

$$\text{Wall thickness} = 0{\cdot}21 \frac{M}{I} \sqrt{A},$$

where A was the cross-sectional area of the ingot in square inches. For example, a 24-in. octagonal mould of 4 tons capacity required a wall thickness of

$$0{\cdot}21 \times 0{\cdot}94 \times \sqrt{504} = 4{\cdot}43 \text{ in.}$$

For slab moulds of increasing broad- to narrow-side ratio (assuming walls of equal thickness), the equation became:

$$\text{Wall thickness} = 0{\cdot}20 \frac{M}{I} \sqrt{A} \text{ in.},$$

for a broad- to narrow-side ratio of 2·0.

Mr. P. Walker, of the Cargo Fleet Iron Company, Limited, was the author of the last of the three papers. This dealt with "Ingot Surface Defects: Formation of 'Double Skin' or 'Curtaining' on Top-Poured Mild-Steel Ingots." In presenting it Mr. Walker said that his results indicated that two factors were of significance, namely, the trapping of deoxidation slag near the ingot surface during solidification and "splash" moving forward from the mould wall and allowing liquid steel to flow behind it. The former factor gave a double-skin effect which was not visible on the surface, and the latter was responsible for a visible double-skin or curtaining effect. When steel was poured into a tarred mould there was absence of curtaining, it being concluded that the splash did not adhere to the tarred mould wall and was immediately taken up by the liquid metal. It had also been noted that ingots which were poured into badly "crazed" moulds did not show curtaining. The absence of the defect on such ingots was concluded to be due to the splash "keying" itself on to the mould wall, and thus not producing a contraction gap into which metal could flow.

The discussion was opened by Dr. L. Reeve, who referred to the development of statistical methods for the examination of works data. In this respect, the two ingot-mould papers were interesting examples of the trend of the times. The so-called Ingot Mould Sub-Committee analysis should not be taken as applying to all sizes of moulds. It had been worked out largely on ingot moulds of about 4 tons capacity and for larger moulds, of 5, 10 and 15 tons capacity, slightly higher silicon values gave rather better results. The next speaker, Mr. W. H. Glaisher, stated that the effect of phosphorus in a mould containing high silicon might be different from the effect in a mould having a low silicon content. An analysis of Mr. Kerlie's results indicated that the effect of lower silicon (namely, less than 1·5 per cent.) was greatest with high phosphorus content (*i.e.*, greater than 0·1 per cent.) and that the effect of high phosphorus was most marked with low silicon. A subsequent speaker, Mr. A. Bevan, said that at the works of Guest Keen Baldwins Iron and Steel Company, Limited, Cardiff, a number of experiments had been set in motion, involving first low-phosphorus and high-silicon moulds, then low-silicon and low-phosphorus moulds, and finally low-silicon and high-phosphorus moulds. The object was to try to get a comparison such as Mr. Kerlie had obtained. Taking all the results as a whole, a definite improvement in life had been obtained with low silicon (about 1 per cent. and less) and high phosphorus (0·2 per cent. and even more). Actually some of the moulds contained as much as 0·5 per cent. of phosphorus, and some of them had the longest lives of all those which had been made. All these experiments and also those of Mr. Kerlie and those of Mr. Bacon at Templeborough, had been made with a 4-ton square mould, not a slab mould. The indications were, certainly in South Wales, that with the rather bad casting-pit practice in places, the Ingot Mould Sub-Committee specification did not improve the life of moulds. Mr. Glaisher had mentioned that the effect of phosphorus was greatest with low-silicon values and this was precisely what had been found at Cardiff.

Mr. W. L. Kerlie in discussing Mr. Bacon's paper stated that, in coming to a conclusion with regard to the desirable M/I ratio the mould might well be considered as consisting of several distinct parts. For example, if the mould had a semi-closed top it might be imagined to be cut off at the top and the M/I ratio based on the lower portion. With semi-closed bottom moulds the same principle would apply, and with moulds having a hot top, the effective M/I ratio would be based on that length which contained solid steel throughout.

Mr. Bacon, in a brief reply, said that there was no question but that many moulds had been made very much too thick, namely from 50 to 70 per cent. thicker than was necessary, with the (as he thought) mistaken idea that it had some effect on the ingot structure. All the work done by the Ingot Mould Sub-Committee had shown that the result was negligible. The very big forging ingots had M/I ratios of 0·6 or less, which meant that they had relatively thin walls. He agreed with Mr. Kerlie that, in considering the M/I ratio, only that portion of the mould which actually contained the steel should be taken into account. Mr. P. Walker also briefly replied to the discussion and the proceedings terminated with the usual votes of thanks to the authors and to all others who had contributed to the success of the meeting.

THE SEARCH FOR MINERALS BY PHYSICAL METHODS.*

By PROFESSOR A. O. RANKINE, O.B.E., D.Sc., F.R.S.

THE search for minerals and rock structures at increasing depths underground when the more accessible supplies became exhausted led to the call for physical methods involving measurements at ground level to detect and delineate what lay underneath. Notable examples of successful operations of this kind were already on record, namely, the discovery of large buried deposits of iron ore, simply by the marked magnetic effect which they produced. No very delicate instruments were required; ordinary compasses sufficed. The largest such magnetic anomaly known is at Koursk, in Russia, and the effect at ground level is so great in places that a compass needle actually reverses its direction pointing south instead of north. This remarkable magnetic anomaly originates from an enormous ore body 150 metres deep, estimated at 20,000 million tons and consisting largely of the oxide of iron known as magnetite. Other similar deposits occur in Sweden, where, also relatively crude magnetic observations are employed and found effective for prospecting. On the broader aspects of the subject, more especially in relation to the search for oil, activity in geophysical prospecting can be said to have started just after the war of 1914-18. Since then, four principal methods have been developed.

There is first the method which depends on the gravitational forces which all material bodies exert whatever their magnitude. Each part of the earth, for example, however small, makes its contribution to the total gravitational pull experienced at the surface. As the various rocks composing the earth's crust are of different densities and are distributed in a non-uniform manner, local variations will be produced—gravitational anomalies as they are called—due to the fact that the denser rocks are more effective gravitationally. The variations of force encountered in practice are extremely small and the instruments employed have to be of great sensitivity. The gravitational method of geophysical surveying simply consists of carrying out systematic surveys with a view to finding gravitational anomalies likely to be associated with underground structures of economic value. The method, in fact, has turned out to be of wide applicability and of great importance in the search for oil fields.

Secondly, we have the magnetic method already mentioned but now refined so as to have a wider scope. The components of the earth's crust have become magnetised to different extents by the earth's main magnetic field. Thus magnetic anomalies are produced at the earth's surface in those regions where bodies are magnetised to a degree greater or less than the average lie underground. The question of whether or not these anomalies can be observed depends on the sensitivity of the measuring instruments available. Great progress has been made in recent years in the development of sensitive magnetometers, and, in consequence, the magnetic method of surveying has become useful not merely for defining very large anomalies like that at Koursk, but for locating ore bodies both much smaller and much less magnetic.

In the third, or electrical method, in the practice of which there are several variations of field procedure, successful operation depends on there being a sufficient difference of electrical conductivity as between the object of search and its surroundings. The most usual method employed is to survey the surface by means of probing electrodes inserted in shallow holes in the ground and connected to a galvanometer. If the artificial current used is direct it is passed into the earth by main electrodes which are widely separated over the region under test. A variant is to work with alternating current, in which case electrodes may be dispensed with. Coils of wire not connected with the earth may then be used instead, both to provide the artificial current stimulus by electromagnetic induction and to detect the response by the same process.

The last of the four main geophysical methods is that known as the seismic method. So far it has been applied chiefly, and more widely than any other method, to the examination of the structure of deeply-buried sedimentary rocks in relation to the conditions favourable to the discovery of oil. Broadly, we are here concerned with two physical properties of various rocks, namely, their relative densities and elasticities in combination. The method is closely related to the study of natural earthquakes; indeed, it is seismology on a small scale, using artificial explosions as the controlled stimulus given to the earth. The fundamental measurements involved are the times that are taken by the earth tremors in travelling from the explosion to the point of observation elsewhere on the earth's surface. These times, in turn, depend upon the various paths by which the tremors proceed and the speeds with which they are propagated in the rock beds traversed by these paths. Now both the paths themselves and the speeds of the tremors are determined by the two physical properties of density and elasticity just mentioned. The various beds of rock encountered as we proceed downwards into the earth are characterised by velocities of propagation which change from bed to bed, generally in the sense of increase with depth. Moreover, at each interface between successive beds, partial reflection and partial refraction of earth tremors occur in a manner similar to the behaviour of light in optics. Both reflection and refraction are used in seismic prospecting; in fact they are the bases of the two modes of operation. In reflection work we observe what are in effect subterranean echoes of explosions at the surface, by means of seismometers. In the refraction method the field procedure is much the same as for reflection, but the distance between the explosion and the recording seismometers has to be much greater.

We come now to the question of the applicability of the geophysical methods outlined to the special problem of locating oil reservoirs. All the four methods mentioned have been applied, but electrical and magnetic surveying have played only a secondary role. It is on gravitational and seismic work, especially the latter, that the best results have been obtained. Quite apart from local anomalies it is well known that gravity varies over the surface of the earth as a whole, being about one half per cent. less at the equator than at the poles, partly due to the polar flattening and partly to the effect of the earth's rotation on its axis. On the average, its value is about 980 dynes per gramme, as expressed in C.G.S. units. One of these units is called a gal (as a tribute to Galileo for his early work on gravitation) and one thousandth of this is a milligal. Now the calculated gravitational effect of one of the buried structures we have in mind rarely exceeds a few milligals, and even one or two tenths of a milligal may be significant. The problem is therefore to compare the force of gravity at one point with that at others to an accuracy of one part in ten million of the total attraction exerted by the earth.

It became known gradually to those concerned that the Hungarian physicist, Count von Eötvös, had many years earlier invented, constructed and used a portable instrument of quite exceptional sensitivity, which we know nowadays as the torsion balance, for the investigation of gravitational anomalies. One of the reasons for the long delay in the application of this remarkable instrument to the search for oil was the reluctance of Eötvös to allow the product of his ingenuity to be used for commercial gain. Ultimately he was persuaded against his inclinations, with the result that several new oil-bearing areas were discovered and the activity on the Gulf Coast of the United States at one time became so great that about 200 Eötvös balances were in use. It is true that in more recent years the Eötvös instrument has been superseded by others of different construction and greater practical utility. But Eötvös has the best claim to be regarded as the father of geophysical prospecting for oil, even if a hesitant one. These newer instruments for measuring variations of gravity, or gravimeters as they are called, are too numerous to be described in detail, but in nearly all of them the principle of the spring balance has been adopted. A constant mass is supported by a spring, and, as its weight varies slightly under different conditions, the spring changes its shape a little, both in length and twist; and from observations of these dimensional alterations the corresponding variations of gravity are deduced. Several modern gravimeters of various types have been proved capable of detecting reliably gravity variations of considerably less than one tenth of a milligal. Nevertheless, they are not so sensitive as the Eötvös torsion balance but they are preferred in practice nowadays as they are much speedier in operation.

In seismic methods the principal part of the necessary equipment is the recording seismometer, a device capable of responding to earth movements often less than one ten-thousandth of an inch in extent. The principle of all seismometers is the same. A heavy mass is supported by a suitable spring in a framework rigidly attached to the earth. The frame therefore moves as the earth does, but the mass does not at once respond owing to its inertia. Relative displacement between mass and frame thus occurs, and it is this which is magnified and recorded photographically on a moving paper or film in the recording camera. It is customary to fire the charges of explosive, to initiate the seismic tremors, in holes drilled to various depths up to 100 ft. or so, tamping them down well so that most of the energy goes into the earth as desired. The instant at which the explosion occurs has also to be recorded on the seismogram which is being made at the observation point some distance away. This is usually achieved by causing the detonation to send out, by means of a trigger, an electrical signal which is transmitted without appreciable delay by radio to the recording system.

* Annual May Lecture, delivered before the Institute of Metals, in London, on Thursday, May 13, 1948. Abridged.

METROPOLITAN LINE IMPROVEMENTS.

THE 1935-1940 programme of new works started by the London Passenger Transport Board before the war, included the extension of the Bakerloo Line northwards from Baker Street to Stanmore, which had formerly been served by the Metropolitan Line, and the provision of additional tracks on the Metropolitan Line to provide four tracks between Harrow-on-the-Hill and Rickmansworth. The intention was to provide better facilities for passengers between the north-west and the centre of London. Much of the civil-engineering work was completed by 1940, and the Bakerloo Line to Stanmore had been opened, when the programme was suspended owing to the war. Work was resumed in October, 1946, and the first major part of the scheme—the alterations as far as the north end of Harrow-on-the-Hill station—is now almost complete. A photograph of the tracks at the north end of Harrow station is reproduced in Fig. 1, opposite. It was taken from the new signal cabin, which is a lofty building at the north end of the station, on Wednesday, May 19, when the alterations to the tracks had been almost completed. Before describing the work in that area, however, it is necessary to explain the reasons for the changes, and review the work that had been completed before the war.

A diagrammatic map of the sections of the Metropolitan and Bakerloo Lines with which this article is concerned, is reproduced in Fig. 2, opposite. Prior to 1935, the services to Stanmore, Harrow, and Uxbridge had been provided by Metropolitan trains from Baker Street station. L.N.E.R. trains from Marylebone, with the first stop at the joint station at Harrow, shared the service from Harrow to Aylesbury and Watford with the Metropolitan Line. From Baker Street to Finchley Road the Metropolitan trains used two sub-surface tracks, but from Finchley Road to Harrow the line comprised four tracks. The local tracks were on the western side as far as Wembley Park, and on the eastern side from that point to Harrow, with a flat junction north of Wembley Park for the Stanmore line, and a flying junction north of Harrow for the Uxbridge line. The flying junction avoided interference between the Uxbridge and Aylesbury services. By means of duplicate double-line junctions north and south of Harrow, the L.N.E.R. and Metropolitan lines merged into two tracks to Aylesbury.

The new works programme provided for the extension of the Bakerloo Line from Baker Street to Stanmore by means of new deep-level tubes from Baker Street to Finchley Road, where the tubes were to come to the surface and the Bakerloo trains were to take over the local service to Wembley Park and Stanmore. The programme also included the introduction of "parallel working" (fast lines on the outside and local lines on the inside) as far as Harrow, to allow platform interchange between fast and local trains at Finchley Road, Wembley, and Harrow; and the construction of a flying junction north of Wembley Park for the Stanmore line. The provision of four tracks on the joint line from Harrow to Rickmansworth (on the Aylesbury line) was also envisaged, to reduce the interference with the electric trains due to the large "headway" required for L.N.E.R. express trains.

The Bakerloo service to Stanmore was opened on November 20, 1939, and, in preparation for this, all surface works between Finchley Road and Preston Road, including the Stanmore flying junction, the reversal of the direction of running on certain tracks, and the consequent modifications to platforms at intermediate stations, had been completed by November 6, 1938. It was necessary to provide a flat crossing north of Preston Road, to allow fast southbound trains to cross the local tracks until such time as the alterations at Harrow had been completed. Although the operating department accepted this restriction on the flow of traffic for a limited period only, owing to the war it had to be retained until March of this year.

The work that had been completed north of Preston Road before the war included the widening of embankments and cuttings in the Harrow area, the rebuilding of Harrow station, the construction of new spans to bridges, and the extension of the deck of the Uxbridge-branch burrowing junction, to the north of Harrow station, to accommodate an additional track. The layout of the tracks at Harrow, as it was during the war, is shown in Fig. 3, opposite, and the new layout—now almost completed—is shown in Fig. 4, opposite. For convenience, both plans have been divided into two parts, the right-hand end of the upper part in each case joining on to the left-hand end of the lower part. It will be seen from Figs. 3 and 4 that two new platforms have been brought into use. The main connections between the Eastern Region lines and London Transport lines have been moved from near the old Harrow south signal cabin to the north end of the area. There are still only two tracks to serve both London Transport and Eastern Region traffic to North Harrow and beyond, but two more tracks will be laid at a later date.

METROPOLITAN LINE IMPROVEMENTS.

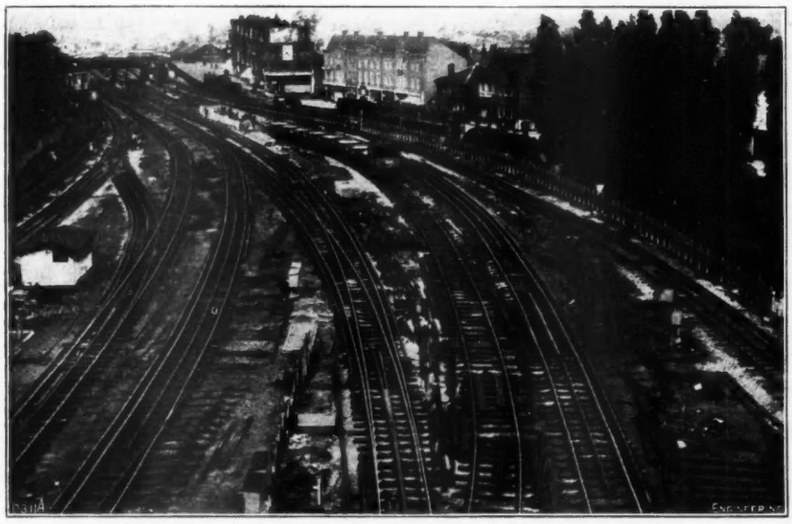
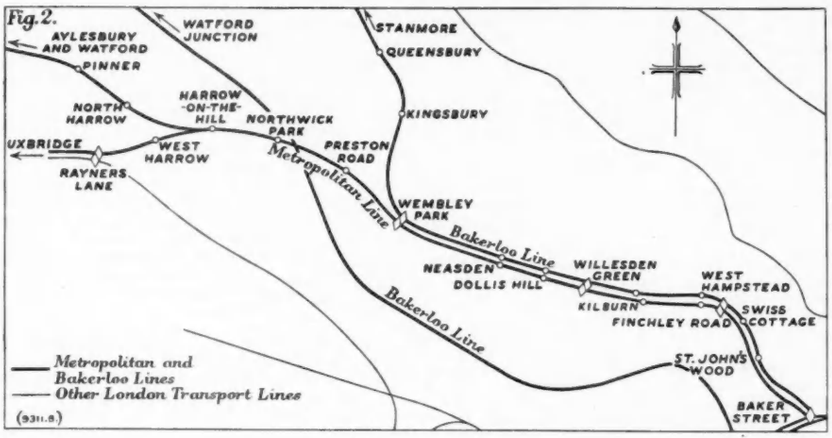
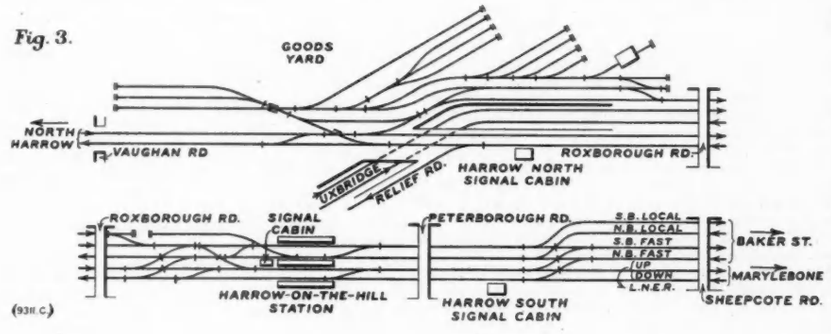
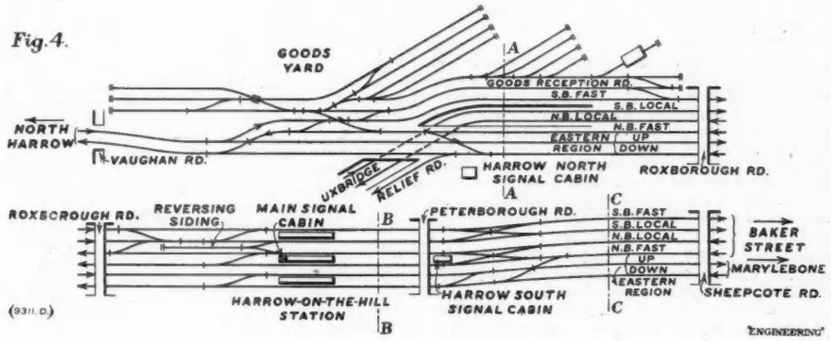


FIG. 1. TRACKS NORTH OF HARROW-ON-THE-HILL STATION.







The temporary flat junction at Preston Road has been removed, and parallel working has been continued through Harrow, as shown in Fig. 4. The local lines become the Uxbridge branch, and the fast lines are brought together north of the burrowing junction, and eventually join with the Eastern Region lines. Thus, apart from the inconvenience of having only two tracks to North Harrow and beyond, the six lines through Harrow can now be utilised to their full capacity. The service on the Uxbridge line during rush hours is to be increased from eight to twelve trains an hour as soon as equipment is available, and, although the service on the Metropolitan fast lines cannot be improved until four tracks are laid as far as Rickmansworth, the facility with which traffic is worked through Harrow-on-the-Hill has been enhanced by the alterations.

The reconstruction of the tracks at Harrow-on-the-Hill has been carried out in six principal stages, culminating, in each case, in a changeover in the track layout and, consequently, the working of traffic. The first stage comprised the laying of as much of the new track as possible without affecting the old layout. Some new tracks were also installed in the goods yard, and the station platforms were extended 30 ft. A small number of men worked on this stage at various times between October, 1946, and February, 1948. Originally, it was hoped to complete the whole scheme last year, but owing to delays in the supply of materials, and other factors, this was not possible. It was therefore necessary to postpone the major work until the spring and early summer of this year. In the event, it proved to be a fortunate circumstance: the weather during the early part of last year was not at all suitable for a major reconstruction of this type, but the weather this year has been ideal.

Normally, the civil and signal engineers were given possession of the line by London Transport operating department from 1.45 a.m. to 4.15 a.m. on week-days, and from 1.30 a.m. to 7.0 a.m. on Saturday-Sunday nights, when the changeovers were effected. Even during these short periods, however, they had to allow for the night traffic of the Eastern Region, but some of this was diverted on to other routes. The five changeovers were carried out at fortnightly intervals between the night of March 6-7 and the night of May 1-2, except that some preliminary work was carried out on the night of February 28-29. The first changeover was important because it brought parallel working into operation from Preston Road to south of Harrow station, and for this purpose the temporary crossing at Preston Road was removed. At the same time, three tracks at Northwick Park station were slewed over so that the new south-bound and northbound local lines remained on each side of the existing single-island platform.

At the second and third changeovers, alterations were made to the tracks in the vicinity of the north signal cabin, in preparation for the new double-line junction and new connections to the goods yard. The old north signal cabin was demolished, and at the fourth changeover the new cabin was brought into use, both main lines at Harrow north were slewed over, and the double-line junction was brought into use. The fifth and final changeover, on the night of May 1-2, necessitated rapid work in the allotted time. The tracks were disconnected at the north and south ends of Harrow station; they were then slewed over and reconnected to bring No. 1 and No. 6 platforms into use. Other alterations were made in the track layout, and the old south signal cabin, which was operated until the cessation of traffic that night, was removed, and track laid over the site, in time for traffic on Sunday morning. Concurrently, the new cabin was put in operation. Prior to laying the new Eastern Region up and down lines over the burrowing-junction bridge, the deck was waterproofed with a layer of asphalt which, in turn, was protected from the ballast by a layer of Ciment Fondu. From May 2 to June 6, all crossovers and a reversing siding at the north end of the station are being completed. Work on the reversing siding is shown in progress in Fig. 1.

The old signalling at Harrow-on-the-Hill was a combination of mechanical points and colour-light signals, with some wire-operated semaphore signals. It has been replaced by a system of power signalling, comprising points and train stops which are operated electro-pneumatically, colour-lights for the running signals, and disc signals for controlling shunting movements. The whole area is track-circuited, and controlled from the main signal cabin at the north end of the central island platform. It is divided into three sections, however, the section north of A A (Fig. 4) being controlled through a "slave" signal cabin, and the section between B B and C C being controlled through another slave cabin. The station section between A A and B B is controlled by the main cabin, although by indirect means to be described. The main cabin contains a frame with 93 levers, of which 40 are push-pull type "route" levers. Each route lever has two positions representing alternative track routes, and when a signalman selects

one position by pushing or pulling the lever, the lever remotely controls one or more air-operated slave levers, each of which actuates a particular point, signal or train stop, to set the required route.

The remotely-controlled air-operated slave levers are situated in the north or south slave cabins, or in the main cabin, depending on the section in which the corresponding point, signal or train stop is situated. The connections between the route lever and the slave levers consist principally of ordinary telephone-type cables, current in which energises magnets in the slave cabin, and the magnets operate valves which admit compressed air to cylinders and move the slave levers. According to the function of a particular lever, it actuates a colour-light signal, or electro-pneumatically operates a point or train stop. In the latter cases, an electric cable is laid to the point or train-stop machine, where compressed air provides the power. Air at 60 lb. per square inch for the slave levers in the cabins and the machines at the line side is supplied from air mains. The slave cabins have no windows; normally they are closed and are not entered except for maintenance. If desired, for emergency or other reasons, however, a signalman can enter a slave cabin, isolate it from the main-cabin remote control, and proceed to control his section by manually operating the "slave" levers. The north cabin contains 44 levers, and the south cabin 33 levers. There is the usual track-circuit diagram, indicating the movements of trains in the section, above the lever frame. The appropriate mechanical and electrical interlocks are situated in each cabin, and, of course, they function whether or not remote control is in use. Mr. R. Dell, M.I.E.E., Signal Engineer, London Transport, has described this type of signalling in a paper* read before the Institution of Electrical Engineers. Most of the signalling equipment for Harrow-on-the-Hill has been supplied by the Westinghouse Brake and Signal Company, Limited, 82, York Way, King's Cross, London, N.1, but the installation was designed and constructed by the Signal Engineer's department, London Transport.

LAUNCHES AND TRIAL TRIPS.

S.S. "SIDI BEL ABBES."—Twin-screw passenger and cargo vessel, built by Messrs. Swan, Hunter, and Wigham Richardson, Limited, Newcastle-upon-Tyne, 6, for the Mediterranean service of the Société Générale de Transports Maritimes à Vapeur, Paris. Main dimensions: 402 ft. by 53 ft. 6 in. by 27 ft. 3 in.; deadweight capacity, about 1,850 metric tons. Parsons single-reduction double-helical steam turbines, installed by Messrs. Swan, Hunter. Two Lamont boilers supplied by Messrs. John Thompson Water Tube Boilers, Limited, Wolverhampton. Launch, April 22.

S.S. "PARAGUAY STAR."—Single-screw passenger and cargo vessel, built by Messrs. Cammell Laird and Company, Limited, Birkenhead, for the South American service of the Blue Star Line, Limited, London. Main dimensions: 501 ft. by 68 ft. by 39 ft. 6 in. to upper deck. Parsons double-reduction turbines, and two oil-burning Babcock and Wilcox-type boilers constructed by the builders. Launch, April 23.

M.S. "BRITISH CHIVALRY."—Single-screw tanker built by Messrs. Blythswood Shipbuilding Company, Limited, Scotstoun, for Messrs. British Tanker Company, Limited, London. Main dimensions: 515 ft. by 69 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, 16,000 tons. Six-cylinder opposed-piston Barclay Curle-Doxford oil engine, developing 6,400 brake horse-power, supplied by Messrs. Barclay, Curle and Company, Limited, Glasgow. Launch, April 27.

H.M.S. "ALAMEIN."—Flotilla leader of about 2,200 tons displacement, constructed by Messrs. R. and W. Hawthorn, Leslie and Company, Limited, Hebburn-on-Tyne, for the Royal Navy. Two-shaft arrangement of geared turbines developing a total of 50,000 shaft horse-power. Armament: twin 4·5-in. quick-firing and twin 40-mm. Bofors guns, with 21-in. torpedo tubes. Trial trip, May 4.

LIGHT VESSEL.—Built by Messrs. Philip and Son, Limited, Noss Shipyard, Dartmouth, for the Corporation of Trinity House, London, the vessel is the seventh of a series of nine. The lantern contains six 500-watt lamps giving a beam visible for 10 to 12 miles. Main dimensions: 137 ft. 3 in. by 25 ft. by 15 ft.; gross tonnage, about 350. Launch, May 7.

S.S. "ERIK BANCK."—Single-screw cargo vessel built by Messrs. William Gray and Company, Limited, West Hartlepool, for Erik Bancks Rederi A/B, Helsingborg, Sweden. Main dimensions: 336 ft. by 46 ft. 10 in. by 27 ft. 10½ in. to shelter deck; deadweight capacity, about 3,500 tons on a draught of 19 ft. Triple-expansion engine, and two oil-fired boilers, supplied by the Central Marine Engine Works of the builders, developing 1,970 indicated horse-power, with a service speed of over 12 knots. Trial trip, May 7.

* *Jl. I.E.E.*, vol. 91, page 400 (1944).

LABOUR NOTES.

IN the course of his opening speech at last week's annual conference of the Labour Party, Mr. Shinwell said: "We have achieved the nationalisation of coal and electricity, and gas will shortly be included. This will give us the opportunity of bringing together the three fuel and power industries into an effective unity and thus pave the way for the creation of vast by-product operations from which may flow many new industries. This means that we cannot afford any longer to use coal—our basic essential raw material—only as a fuel. We must move away from old-fashioned methods, and treat this most precious asset as a source of new raw materials."

Mr. Herbert Morrison, Lord President of the Council, said in the course of his speech to the delegates, that the Socialist programme for the next election must be a programme of reality. "We must make it as attractive as we can," he declared, "to ourselves, but we must make it also attractive to public opinion."

The annual conference of the National Union of Hosiery Workers—which was held at Llandudno last week—rejected a proposal that the union should affiliate to the Labour Party. In a ballot on the subject, 12,049 votes were cast against affiliation and 9,394 votes in favour of affiliation. Sixty-seven per cent. of the members of the union voted. Commenting on the decision, Mr. H. M. Moulden, the President, said it would be wrong to assume that the result was an indication of antagonism by their people towards the Labour Party. He was satisfied that it was not and that it was but a reflection of the desire of quite a large number of members to keep politics out of their industrial discussions.

Addressing the Labour Party conference on Tuesday, Mr. Morrison said that they now had to face up to the responsibilities of leadership and clear the cobwebs out of their thinking. If they failed to do so, the electors might judge the performance in a "brutal and unpleasant" way. The first stage of the "peaceful revolution" was over. Many new laws had been passed by Parliament. We were getting to that very perilous stage in which previous revolutions had sometimes foundered. That was the time when the ideals set out in the programme had been given the force of law and the frame-work had been set up to carry them out.

"The ball," Mr. Morrison went on, "is now passed back to the citizen. It is the citizen's task to match the new legislation with a new spirit and new effort. Vast cheques have been drawn on the future. We cannot meet them by squeezing capitalists any further. They can be met only by producing more. Labour must be sure it is not indulging in, or abetting, restrictive practices through the unions. A long-term plan of re-equipment is needed so that in ten or 15 years we can look forward to a really efficient and modern British industry. Meanwhile, output could be increased with existing labour and machinery."

Mr. Dalton forecast to the conference that if industry did not voluntarily cut profits, a new tax would have to be thought up on the lines of the Cripps "once-for-all" levy on unearned incomes. Clearly, the ex-Chancellor of the Exchequer said, the next Parliamentary programme must depend on the conduct of private enterprise. The conference rejected the more critical of two pay and profit resolutions. It was moved by Mr. Jack Stanley of the Constructional Engineers and demanded more price controls, new subsidy cuts, higher profits tax, reduced rents, and an emergency capital levy. The other resolution—which was adopted and apparently had the approval of the National Executive—called upon the Government and the T.U.C. to devise together a more satisfactory policy on prices and incomes and expressed doubt that profits could be effectively controlled by a mere reliance on voluntary effort on the part of manufacturing and trading organisations.

Mr. Morrison told the conference at Scarborough that a committee of scientists had been set up to advise the National Executive of the Labour Party. Professor Laski will be chairman, and will report regularly on (1) How science can be used to better the conditions of employees, (2) How it can increase output and lower costs, (3) How atomic energy can be applied to industry. The standard of living for which the national executive can ask the Government to legislate will depend to some extent on the Committee's work.

According to figures compiled by the Ministry of Labour and National Service, 49,000 men and women left British industry in March—more than the combined total who left in January and February. The Ministry does not regard the figure as alarming; in its opinion, it is not really very high. It is caused by old age, sickness, and retirement.

It is officially stated that the total working population in this country declined during March by 12,000 men and 29,000 women, and at April 14, the number of insured persons registered as unemployed was 300,800, compared with 299,400 at March 15, representing at both dates about 2 per cent. of the insured population. The only large industrial group in which there was increased employment was textiles, where there was an increase of almost 2,000 in the cotton industry, 1,300 of them women. There were also small increases in two other industries for which man-power targets had been set in the economic survey for 1948—3,000 additional persons in agriculture and 700 in coal-mining. The number of foreign persons (including ex-prisoners of war given civilian status) placed in employment during March was about 11,000.

At Wednesday's sitting of the Labour Party conference, Mr. J. B. Figgins, of the National Union of Railwaymen, spoke of the disillusionment and complete dissatisfaction of his members since the Government had taken over the railways. He called for a complete shake-up from top to bottom of the Railway Executive. His views appeared to be shared by many other delegates, but the criticism collapsed when Mr. Lawther, of the National Union of Mineworkers, and Mr. Deakin, of the Transport and General Workers' Union, announced that the huge block votes of their organisations would be used against Mr. Figgins' resolution. A resolution proposed by Mr. Jim Griffiths, Minister of National Insurance, proposed that the matter should be referred to the National Executive for joint consideration by it and the Trade Union Congress General Council.

Under the provisions of the Indian Trade Union (Amendment) Act, 1947, a registered trade union which has applied to an employer for recognition and has failed to obtain recognition within a period of three months may apply in writing to the Labour Court for recognition by the employer, setting out such particulars as may be prescribed. If, after due investigation, the Labour Court is satisfied that the trade union concerned satisfies the conditions for recognition laid down in the Act and is fit to be recognised by the employer, it shall make an Order directing such recognition and may, where the recognition is to be by an association of employers, further direct by the same, in a subsequent Order, direct recognition by every member of the association in relation to whom the trade union fulfils the conditions prescribed for recognition.

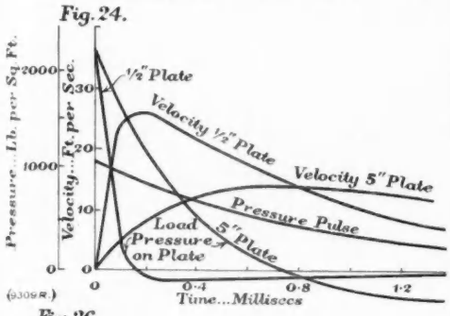
The Act lays down that a trade union shall not be entitled to recognition by order of a Labour Court unless it fulfils the following conditions: (*a*) unless all its ordinary members are workmen employed in the same industry, or in industries closely allied to it or connected with one another; (*b*) it is representative of all the workmen employed by the employer in that industry or those industries; (*c*) the rules do not provide for the exclusion from membership of any class of workmen; (*d*) the rules provide, in the procedure for dealing with disputes, for a meeting of the executive once every six months; (*e*) it is a registered trade union and has complied with the provisions of the Indian Trades Union Act.

The Factories (Amendment) Act of 1948, which received the assent of the Governor of Burma on December 27, 1947, reduces the maximum permissible hours of work for factories in Burma from 54 to 44, increases the rate of pay for overtime work from one and a half to twice the ordinary rate, raises the minimum age of admission for employment in factories from 12 to 13, and reduces the permissible daily working hours of children from five to four. It is provided that in every factory, prime movers, transmission systems, and other machinery shall be securely fenced by safeguards of substantial construction. The provision relating to cooling in factories is substantially amended, and the Chief Inspector is empowered to require the manager of a factory to carry out specified measures before a prescribed date. The proviso in the original Act that such measures should not involve expense which is unreasonable in the circumstances is deleted.

Under the new Norwegian "Holidays with Pay" Act, every person employed in the service of another is entitled to an annual holiday, with the exception of those whose remuneration consists exclusively of a share in the profits, or who are closely related to the employer, or who are covered by the Public Employees' Act of 1918, or are Civil Servants, or who are in part-time posts where it is anticipated that the employment will not involve more than a total of 200 hours' work in a calendar year, or where remuneration is on a commission basis only.

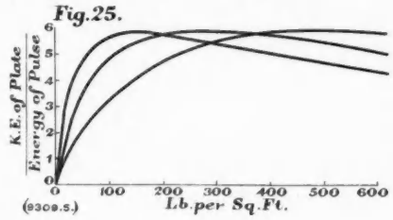
EFFECT OF NON-CONTACT EXPLOSIONS.

Fig. 24.



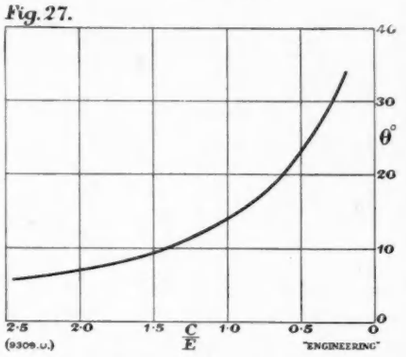
(9309.R.)

Fig. 25.



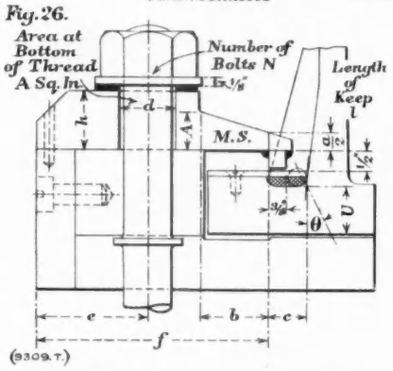
(9309.S.)

Fig. 27.



(9309.U.) "ENGINEERING"

Fig. 26.



(9309.T.)

EFFECT OF NON-CONTACT EXPLOSIONS ON WARSHIP MACHINERY DESIGN.*

By COMMANDER (E) A. D. BONNY, R.N.

(*Concluded from page* 503.)

THE following is the method of calculation of the effect of a pressure pulse on an unrestrained flat plate and its relation to the effect on items of machinery and equipment. The motion of a machinery mass in a ship acted on by a pressure pulse will involve the masses of the plating, framing, seating, and the machine itself, together with the stiffnesses of the seating relative to the framing, the framing to which the seating is secured relative to the hull as a whole, and the panels of plating: and will thus form a complex spring system, the mathematical solution of which does not enable the motion of the mass to be readily interpreted. Partial solutions, in which some of the components are considered negligible, provide some indication of the motion, but are still complex. It would appear, however, that a useful insight into the motion can be obtained from consideration of the simple case of the pressure pulse acting on an unrestrained free plate, followed by an appreciation of the effect on this motion of the various other factors involved.

Neglecting the enhanced values of velocity of pulse, etc., that occur close to the charge, there is formed from an under-water explosion a spherical pressure pulse radiating outwards at the speed of sound in water (5,000 ft. per second) and having a pressure at any instant :—

$$p_1 = p_{max.}\, e^{-nt}, \text{ where } p_{max.} = C_1 \frac{W^{\frac{1}{3}}}{D} \text{ tons per sq. in.,}$$

and

$$n = \frac{C_2}{W^{\frac{1}{3}}} \frac{1}{\text{sec.}}, \text{ and W = weight of explosive.}$$

The values of C_1 and C_2 are obtained experimentally.

This pressure acting on a free plate, mass m per unit area, is in part reflected, and the combined force due to the incident and reflected pressures accelerates the plate; thus

$$p_1 + p_2 = m\ddot{x},$$

while, from consideration of the particle velocity of the water being equal to the plate velocity, $p_1 - p_2 = \rho c \dot{x}$, ρ and c being density and velocity of sound for sea water. Hence

$$m\ddot{x} + \rho c \dot{x} = 2p_1 = 2p_{max.}\, e^{-nt}.$$

Solving the above equation of motion gives

$$\dot{x} = \frac{2p_{max.}}{\rho c - m n}\left(e^{-nt} - e^{-\frac{\rho c t}{m}}\right),$$

and the pressure and velocity will vary with time, as shown in Fig. 24, which illustrates the effect of a charge of 250 lb. of T.N.T. at a distance of 80 ft. The velocity is a maximum at

$$t = \frac{1}{n}\frac{\log_e \mathbf{Z}}{\mathbf{Z} - 1} \text{ where } \mathbf{Z} = \frac{\rho c}{m n}.$$

The pressure on the plate is then zero, and the value of the maximum velocity is given by

$$\frac{2p_{max.}}{\rho c}\, \mathbf{Z}^{\frac{1}{\mathbf{Z}-1}}.$$

The energy in the pressure pulse in the water is given by

$$\int_0^\infty \frac{p^2}{\rho c}\, dt, \text{ where } p = p_{max.}\, e^{-nt}$$

$$= \frac{1}{2n}\frac{p^2_{max.}}{\rho c},$$

while the K.E. of the plate at maximum velocity $= \frac{1}{2} m V^2_{max.}$ Hence the proportion of energy absorbed by the plate

$$= m \frac{4p^2_{max.}}{\rho^2 c^2}\, \mathbf{Z}^{\frac{2}{1-\mathbf{Z}}} \frac{n\rho c}{p^2_{max.}}$$

$$= \frac{4mn}{\rho c}\, \mathbf{Z}^{\frac{2}{1-\mathbf{Z}}}$$

$$= 4\mathbf{Z}^{\frac{1+\mathbf{Z}}{1-\mathbf{Z}}}.$$

Thus the proportion of energy absorbed by a free plate is a function of the thickness of plate and charge weight. Fig. 25 gives values of this ratio for typical charge weights.

The various experiments carried out on ships show that, over the range of mass loading and charge weight employed, there is a definite relationship between the velocity of items and the energy in the pressure pulse, the energy transmitted being of the order of $\frac{1}{4}$. This agrees closely with the proportion of energy absorbed for similar cases given in Fig. 25, so that it seems desirable to investigate further the complex motion of a ship's plating to see if some such simple generalisation does sufficiently cover the actual state of affairs to permit its use within limits.

The hull plating of a ship may have considerable curvature, particularly in the transverse plane, and is divided into panels by transverse and longitudinal frames. These frames, in turn, will be the foundation of seatings for masses or bulkheads. Taking a specific seating for a mass secured, say, to two consecutive frames, then the adjoining half panels will contribute to the motion. The area contributing to the motion is generally easier to assess as regards the transverse frames than the longitudinals, where the curvature of the plate makes a fair estimate of areas involved more difficult. For a panel of average size and an explosion at a non-lethal distance and on a line normal to the plate, the pulse will reach all points on the panel simultaneously, and each part will start as a free plate until there is sufficient relative deflection to cause other forces to act.

The plate at the centre is of small mass and relatively lightly constrained at the start, and will rapidly reach its maximum velocity with only a small displacement relative to its edges. Once it has reached maximum velocity, the pressure in the water tends to become negative and cavitation may set in, the water breaking at a point close to the plate. The plate, if undisturbed, would then dish inwards to a maximum relative deflection at a quarter of the period of oscillation of a plate constrained at the edges (this is not strictly true, since the time to maximum velocity may not be very small compared with the quarter period). However, as the plate comes to rest in space (which occurs at a point after maximum deflection), any cavitation will close up, if this has not occurred previously due to the arrival of diffracted pressure waves; and the quarter cycle back to zero relative deflection will be prolonged and the vibration, after the point of maximum deflection, heavily damped by this bringing to rest of the cavitated water. This reloading after cavitation, in theory, increases the energy absorbed by the plate, but, since it occurs after the maximum relative deflection of the plate and when other forces are coming into play, its influence is probably fairly small.

In the case of motion of frames at the edges of panels, the weight per unit area is much higher and the time to maximum velocity will be considerably greater than the centre. The centre of the plate will, therefore, dish inwards and exert a force on the boundaries until the time when the plate is once more flat. Thus the boundaries will be acted on by two forces, namely, the initial force due to the pressure on the plate adjacent to the boundaries; and the force due to the dishing of the centre of the plate, which is a maximum at maximum relative deflection and lasts until the relative deflection is zero. Of the energy of this second motion, part will be given up in increasing the velocity of the boundaries and part will remain in the vibration of the plate, while some further energy may be added due to reloading after cavitation.

Since the pulse will reach adjacent panels at a slightly later time, these panels will lag behind and exert a restraining effect at first, but will similarly tend to increase the effect at a later stage. Since the adjacent panels are farther away (an explosion at a point subtending a perpendicular to the plate is being considered), the energy reaching them is less and the overall result on the panel under consideration is a slight delay in reaching the peak velocity together with a slight loss of energy to adjacent sections.

It is seen, therefore, that the time to maximum velocity of an item in a ship is greater than that of a uniform flat plate, owing to the effect of the dishing of the panels, and this is further prolonged by the influence of adjacent panels and possibly by reloading after cavitation. However, the energy absorbed by the mass, its seating, and the plates and frames does not differ very much from the case of the uniform plate, the variations being that less energy is absorbed by the light central portion of a panel, more energy is absorbed by the heavy edges of a panel, energy is left in the panel vibrating between the frames, and further energy is added by reloading after cavitation. Assuming that these effects approximately balance, the energy of the item and its associated framing and plating may be equated to a proportion of the energy impinging on the area contributing to the motion as given in Fig. 25, and approximating to one-half over a wide range. This is found to be in agreement with trial results.

Although the similarity to the free plate only holds for a short period of time, it can also be used to illustrate another aspect of the motion involving energy principles, namely, the oblique incidence of pressure pulse. In general, the line from the charge to any item will not be normal to the plating under the items, but, from hydrostatic principles, it is clear that the pressure in the water must act normally to any surface with which it is in contact. Secondly, the energy radiated in a pulse is uniformly distributed over a spherical layer so that, whatever the angle between the plating and the line to the charge, only a certain amount of energy proportional to the area normal to the line to the charge falls on the plate and gives rise to velocity normal to the plate.

When, therefore, considering the motion of an item on a flat plate, its velocity normal to the plate should vary as $\sqrt{\sin\theta}$, where θ is the angle between the plate and the line to the charge. In the other extreme case of a circular hull moving as a solid body, the motion normal to the hull of an item will vary as $\sin\theta$, where θ is the angle between line from item to centre and line at centre normal to direction of charge. In either case, the pressure pulse diffracts round corners, and various reflections will be obtained from earlier impingements interfering with the pulse, particularly if cavitation occurs; so that the above figures for the effect of angle will not be so accurate, particularly where θ is small.

In addition to the peak velocity of an item, an approximation to its acceleration up to this point is required. Here the free plate does not act as a useful

* Paper read at the Spring Meeting of the Institution of Naval Architects, held in London, March 17 to 19, 1948. Abridged.

guide, and it is only possible to assess this acceleration as the result of the two forces previously noted. The first of these is the force due to pressure pulse on the plate adjacent to the boundaries: this will cause an acceleration of $\frac{2p_{max.}}{m}$ at the start, falling to zero before maximum velocity, but since no relative motion has occurred the area concerned will be small and m high. The second is the force due to dishing, starting from zero and working up to a peak and then back to zero. The acceleration due to this will, therefore, be a function of the period of oscillation of the plate.

These forces, one diminishing and the other increasing to a peak and then falling, followed by the influence of adjacent panels, give rise to a fairly constant acceleration over the initial stage followed by a diminishing acceleration up to maximum velocity, and this is typical of most velocity-meter records obtained. The initial value of the acceleration due to the first force is not readily assessed, but will obviously be greater for strong framing, such as submarines, than for weak. For other than such specific cases, it would appear that, to a first approximation, the accelerations are comparable on a basis of the period of oscillation of the plating and mass loading.

As soon as the possibilities of damage due to shock had been appreciated, steps were taken to put in hand modifications to minimise the likelihood of damage to existing machinery. Since one of the major causes of damage was the decelerating forces causing fracture of the feet, action was taken to modify the keeps and holding-down arrangements so that these parts should be weaker than the feet. Damage was particularly frequent at the sliding feet end of main turbines, while fracture of these led in many cases to damage at the connection to the gearcase, and the sliding feet keeps were therefore modified on the following lines.

To avoid an excessive bending moment in the foot, the protruding part of the keep had to be designed to bend at a safe load. Equally, the deflections had to be kept to a minimum and the greatest amount of energy was required to be absorbed in the bending of the keep. This condition was satisfied by making the keeps of mild steel and designing the protruding part to a parabolic contour or a close approximation to it. In addition, the holding-down bolts of the keep should not yield before the keep itself, and to satisfy these requirements the keeps were made as shown in Figs. 26 and 27, on page 525, the dimension a being given by the two formulæ for which equal values of a should be obtained.

$$a = 0{\cdot}54t \sec\theta \sqrt{\frac{b}{c + \frac{t}{3}\tan\theta}} \quad \text{(bending of keep)}$$

(θ as in Fig. 27)

$$a = 0{\cdot}5\sqrt{\frac{A\,e\,b\,N\,p}{l\,f}} \quad \text{(stretching of bolts).}$$

The dimension b, if possible, should be not less than a, and the product $a\,b$ as large as possible and in general not less than 0·75 sq. in. The value of p in the above formula should be taken as 16 tons per square inch for mild-steel bolts, and up to 40 tons per square inch for high-tensile steel bolts of an ultimate tensile strength of 55 to 60 tons per square inch.

The thickness of h of the keep should be made

$$= 1{\cdot}1\,a\sqrt{\frac{l\,(f-a)}{b\,(l - N\,d)}}.$$

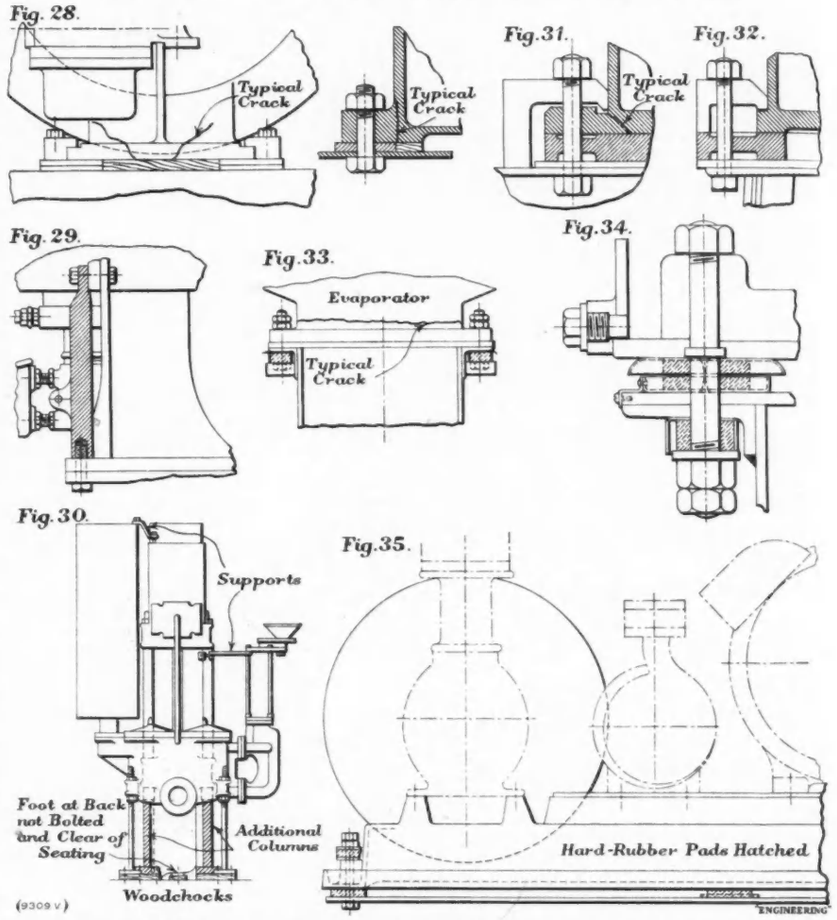
In addition, thin compound rubber washers are to be inserted under the nuts of the holding-down bolts. The nuts should be hardened down as much as possible without "flogging," and locked.

In many cases, the packing pieces and clocks between the machine and seating were badly placed from a shock aspect, in that they did not extend under the main webs and caused fractures due to the accelerating forces causing bending moments or shear in the main casting. In such cases, extra hardwood chocks were fitted, a typical case being shown in Fig. 28, on this page.

To lessen the forces due to overhanging masses, ties or brackets were fitted in many cases to reduce risk of fracture, as shown in Fig. 29, which illustrates strengthening ties fitted to a turbine yoke. Extra supports to Weir pumps were fitted as in Fig. 30. By fitting extra holding-down bolts and clamps, it is possible to reduce the forces involved, and Figs. 31 and 32, show a typical modification of this kind to a plummer block; the former illustrates the alteration to the holding-down bolt to lessen the bending moment, and the latter, the method of fitting additional intermediate holding-down bolts. Alternatively, decelerating washers were fitted under the nuts of the holding-down bolts, as shown in Fig. 33.

By fitting hard compound rubber washers under the machine and under the nuts, it is possible to reduce stresses due to both upwards and downwards forces, and typical examples of how this can be achieved are shown in Figs. 34 and 35. Where the presence of unbalanced forces makes this type of mounting unsuitable, rigid resilient mountings are fitted instead.

EFFECT OF NON-CONTACT EXPLOSIONS.



THE DEVELOPMENT OF THE OPEN-HEARTH FURNACE.*

By SIR ANDREW MCCANCE, D.Sc., F.R.S.

(*Concluded from page* 499.)

The problems of organisation in cold-metal shops centre round the supply and handling of the pig iron and scrap and the correct timing and sequence of these operations. The scrap, etc., is handled by magnets and is dropped into the charging boxes situated on a fixed bench in the marshalling bay and immediately in front of the furnaces. Magnet cranes for this service must be built more than usually strongly and have powerful motors. Their maximum rate of length or cross travel is not of such importance as their powers of acceleration, for the movements at work are restricted to short distances for speedy handling. There are few existing cranes in Colvilles Limited which have not had their motors replaced with larger units since they were first installed in an endeavour to quicken the filling of boxes.

This, in turn, has created another problem, for, with rapid starting and stopping, the swinging of the magnet is greatly increased and control by the operator requires more skill if the time saved is not to be lost again by waiting for the magnet to steady. Swinging is inevitable with a single rope, and after carrying out experiments with models, a four-strand magnet crane was designed which has proved successful in appreciably reducing magnet swinging during operation.†

The weight which a charging box will hold depends on its cubic capacity, and relating the charging time to the capability of the furnace to deal effectively with the weight of the cold materials involved necessarily implies also that the cubic capacity of the charging box bears some relation to these factors. The most important of these in this particular respect is the hearth area which controls the amount of heat received by the charge. Consequently, the cubic capacity of the charging box should vary with the hearth area and like it, therefore, should be proportional to the square root of W, the charge weight. An approximate rule which seems to be adequate is:

$$\text{Cubic capacity of box} = 3\sqrt{W}.$$

While it is not suggested that such a relation should be an exact one, it may prove a useful guide in the formulation of a basis for design which is self-consistent.

It is interesting to record that the first charging machine designed by Wellman for a 40-ton furnace used a box 6 ft. by 24 in. by 18 in., with a capacity of 18 cubic ft.—not very different from many of the boxes still used in Britain to-day. Admittedly, larger boxes require larger doors with larger arches, and large arches are the cause of a good deal of trouble. But it is not easy to understand a certain reluctance in this country to adopt the water-cooled arch which gets rid of this trouble and opens the way to a great many other operating advantages at a relatively slight increase in maintenance and supervision. Its use is certainly essential if larger charging boxes are to be employed and the improvement in the output of greater capacity furnaces relatively cannot be achieved without them.

Boxes proportioned in this way will allow an adequate charging rate to be realised, a proper figure for which in future should be not less than 40 per cent. to 50 per cent. of the capacity per hour. It may be thought that this figure is somewhat high and that existing furnaces are not able to take their charge so quickly. But to be given the equipment and machinery capable of such a performance encourages the desire to take advantage of it and few furnace operators could resist temptations of that kind if placed in their way.

There are two distinct stages in the course of a cold-metal charge during which the transfer of heat to the charge is controlled by very different conditions. In the charging and melting periods, the furnace is in process of filling or is filled with cold material and the charge can absorb a large proportion of its heat requirements by direct radiation and conduction from the flame, since the opening of the doors and the cooling effect of the charge on the walls reduces their tempera-

* Presidential address delivered at the 79th annual general meeting of the Iron and Steel Institute, held on Wednesday, May 5, 1948. Abridged.

† This crane was designed by Mr. T. W. Hand and constructed by Messrs. Russell and Company, Motherwell.

ture and consequently their contribution to the radiation energy of the furnace chamber. Melting is therefore greatly facilitated by a hot intense flame directed down and through the charge.

For intense combustion, furnaces fired by compressed coke-oven gas burners have marked possibilities in regard to future development in the industry. When melting is complete and the charge is level, new conditions arise where heat transfer by direct radiation from the flame is secondary to radiation from the hot walls of the furnace chamber. The bath of liquid steel covered with slag is absorbing heat because of the chemical reactions and conduction through the hearth and so is at a lower temperature than the furnace walls and roof. It is receiving more heat by radiation than it gives out, and this difference is supplied by heat from the flame.

The bath temperature is usually about 1,600 deg. C. The limit of the wall and roof temperature with silica bricks can be taken as 1,650 deg. C., and in those circumstances the percentage of the total heat received by the bath which the flame must supply to maintain steady conditions is 11·1 per cent. If the use of basic bricks would enable the furnace walls and roofs to be run at 100 deg. C. higher in temperature, the rate of heat input into the bath from the flame could be raised to 36 per cent. instead of 11 per cent., and this would obviously benefit the rate of working greatly. Such developments, it is well known, are already in active progress.

Within the past 20 years great progress has been made in our understanding of the physical chemistry of steelmaking processes, and the work of investigators in this country and abroad has now enabled a tolerably clear picture to be formed of the nature of the chemical reactions which take place and of the limitations in our control over them. It is much too large a field to be reviewed even briefly, and I shall only touch on certain aspects in connection with present and future rates of steel production. The refining of steel in the open-hearth furnace is fundamentally a slag-metal interaction, controlled by the composition and temperature of the two phases and the extent of their surface of contact. The role played by the furnace atmosphere, while not without importance, must be regarded as secondary to that played by the slag. During the finishing stage, good steelmaking requires that slag composition must approximate to equilibrium conditions and this restricts within certain limits possible variations in slag composition.

It seems unlikely, therefore, that any great improvement in production rate can be expected from mere changes in slag composition. On the other hand, the dependence of reaction rates on diffusion across the slag-metal interface makes them sensitive to changes in the extent of that surface. The extreme rapidity of the chemical reactions in the Bessemer converter is very greatly assisted by the intense agitation and the large surface of contact thus created between the metal and the slag. But while this principle is clearly understood, it cannot be said that attempts to make use of it in open-hearth practice have met with any success as yet. It is a line of advantage that still awaits the right inventor. The use of oxygen holds out prospects for the rapid production of steel which we can apprehend but which at the present time we are wholly unable to assess.

The first waste-heat boiler in an open-hearth furnace was installed by McKenzie at Motherwell in 1898. This boiler was an ordinary Lancashire type and it interfered so much with the furnace draught that it had to be removed. Not until an induced-draught fan was added to a Babcock type boiler 14 years later was success achieved and 4,500 lb. to 5,000 lb. of steam per hour obtained from a 45-ton furnace. With the ever-increasing cost of fuel the need for recovering waste heat to-day is greater than ever. Even in a well designed furnace, to attain a high production rate inevitably entails some extravagance in the use of fuel since quick melting cannot be obtained without some sacrifice of efficiency in heat transfer. With a waste-heat boiler the excess heat can be recovered as steam while the use of the exhaust fan gives more control over the furnace draught and a wider range of draughting conditions.

For the greatest heat recovery all flues should be encased in steel and heat-insulated, and experience has shown that the cost of doing this is well justified. The flue gases are generally at a temperature of 550 deg. to 650 deg. C., and after passing through the boiler leave at about 250 deg. C., so that the temperature extraction efficiency is about 60 per cent. There are great difficulties, no doubt, in the recovery of the remainder, but the cost of fuel justifies the most serious attempts being made to get this remaining heat back into the works economy. In his original scheme, McKenzie used economisers for this purpose, but this was not altogether a success and was abandoned. The great obstacle is, of course, the presence of SO_3 in the flue gases and the corrosive effects whenever the temperature falls below the condensation range. At present, with efficient fire-tube boilers, 14,000 lb. to 15,000 lb. of steam per hour at 200-lb. pressure are being recovered regularly from 90-ton open-hearth furnaces. During the war, when large quantities of oily steel turnings were used as scrap, the steam recovered during the charging period sometimes reached astonishingly high figures owing to the heat recovered from the burning oil.

Waste-heat recovery is also applicable to soaking pits, and in order to reduce the capital cost involved a scheme has been worked out for discharging the waste gases from two soaking pits independently through each half of a single boiler. This has worked well and approximately 3,000 lb. of steam per hour are being recovered from the heating of 2,200 tons to 2,600 tons of ingots a week. While all schemes have not yet been completed the total coal saving due to waste-heat recovery within the works of the Colville Group already amounts to almost 100,000 tons each year. Heat is not the only waste product in our industry which will repay study and attention, and I will conclude by saying that it is only a determination to find some use for all the products which have hitherto been regarded as waste, as well as by a correct understanding of all the factors concerned in intensive production, that we can hope to maintain the economic success of the steel industry in these unbalanced and difficult times.

FIXING WIRE-ROPE SOCKETS.

THE attachment of a socket to the end of a steel-wire rope can be a troublesome operation, especially if it is to be carried out on a site where few facilities are available, or in a mine where heating by an open flame is not permissible. Splicing demands skill, and socketing by the hot white-metal process requires both skill and heat to melt the metal. A simple component which facilitates the operation considerably has been made for some years by Messrs. British Ropes, Limited, Doncaster. It has been improved in detail from time to time, and although originally intended for use in collieries, it has been applied in many other industries. A description of it in its present form may therefore be of interest.

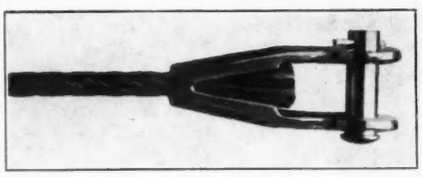


FIG. 1.

Fig. 2.

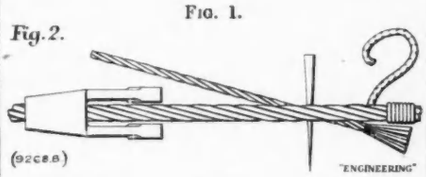


Fig. 1 shows a socket that has been fitted to a rope by the process, the socket having been partly cut away to reveal the method of fixing. A white-metal cone, with six longitudinal grooves to receive the six strands, is placed inside the strands at the end of the rope, and the whole fitted into the coned interior of the socket. The white-metal cone is held in position by a "tail" of wire rope, about 2 ft. in length, which is cast co-axially in the cone, and extends for the remainder of its length inside the main rope, in place of the core strand which has been removed for this purpose. The time taken to fit a socket is comparatively short; for example, one can be fixed to a $\frac{5}{8}$-in. wire rope in five minutes. The strength of the connection is 95 per cent. of the strength of the rope, the socket is short and light, the connection can be readily inspected for defects, and the system is applicable to open or closed sockets made to British Standard Specification No. 463 of 1943.

The socket is first slipped along the rope, a few feet from the end, out of the way. A spike is pushed through the strands of the rope at a distance from the end equal to the combined length of the white-metal cone and the 2-ft. tail. At this point the core of the main rope is pulled out, and is gradually removed, up to the original binding at the end of the rope, by working the spike along, following the lay of the main rope strands. The tail of the cone is now inserted in the opening formed by the spike, and pulled through until it occupies the position shown in Fig. 2. A temporary whipping, not shown in Fig. 2, is reeved on the rope to hold the tail at its junction with the cone (immediately to the right of the spike, in Fig. 2). The whole length of the tail is then fitted into the rope, to replace the cores, by working the spike back along the rope. The original rope-end binding is removed, and the core is finally discarded. The strands are laid in the grooves formed in the cone, the rope is permanently bound with fine wire in the region of the small end of the cone, and the temporary whipping is removed. The socket is now pulled on to the end of the rope, and the job is complete. The tail strand supplied with the cone is made slightly larger than the core of the rope, to ensure that it is held tightly. The "S S" (safe, simple) tail cone, as it is called, is available to suit wire ropes, $\frac{3}{8}$ in., $\frac{1}{2}$ in., $\frac{5}{8}$ in., $\frac{3}{4}$ in., $\frac{7}{8}$ in., and 1 in. in diameter.

NOTES ON NEW BOOKS.

Atomic Energy: Its International Implications. By SIR HENRY DALE, O.M., F.R.S., and others. The Royal Institute of International Affairs, Chatham House, St. James's-square, London, S.W.1. [Price 4*s.* net.]

THE Study Group which was appointed in September, 1946, by the Council of the Royal Institute of International Affairs "to consider problems in international relations arising out of the discovery of atomic energy" consisted originally of 13 members, including Sir Henry Dale, who was the chairman, and Dr. H. E. Wimperis, who acted as *rapporteur*. There were some subsequent changes in the membership, but broadly it may be stated that the Group had at their disposal a combination of scientific knowledge and enlightened judgment hardly to be paralleled even in the United States, where so much of the practical work of developing atomic energy was carried out. The results of their deliberations, as here set out, fall into two main sections dealing, respectively, with the production and application of atomic power, and the crucial problems of controlling it. An introduction by Sir Henry Dale states the objective of the Group, and an excellent bibliography points the way to more extended study. Diagrammatic appendices illustrate the processes using uranium to produce atomic energy, a flow chart of these processes, and a suggested method of control, to be directed by the United Nations Organisation.

Handbook to the Factories Act and Truck Acts. By JOSEPH OWNER. Third edition. Sir Isaac Pitman and Sons, Limited, Parker-street, Kingsway, London, W.C.2. [Price 7*s.* 6*d.* net.]

FROM the beginning of the industrial revolution, a succession of statutes dealing with the welfare of factory workers has been enacted. Under almost every statute, rules and orders having the force of law have been made, so that the whole now represents a formidable body of law. It is the duty of an employer and his administrative staff to be generally familiar with the principles of the law, and to have precise knowledge of its application in their particular industry. Failure to acquire precise knowledge of detailed regulations may lead to difficulties and financial loss, for ignorance of the law excuses no man. This knowledge is therefore vital, but the acquisition of general principles, though not so vital, may be a toilsome process because of its extent. The present book eliminates the toil by describing in terms easy to understand the many provisions of the Factories Act, 1937, and their application to the different industries covered by it. After dealing with the premises to which the Act applies (which include other places besides factories), he describes the requirements of the Act in respect of structures, health and welfare, safety, accidents and dangerous processes, and the employment of young persons and women. The book also deals briefly with the cognate subject of the Truck Acts, which regulate modes of payment. There is a useful appendix listing various departmental memoranda, official and semi-official pamphlets, etc., dealing with safety provisions and welfare generally.

Crosville: The Sowing and the Harvest. By W. J. CROSLAND-TAYLOR, M.C., M.Inst.T. Littlebury Brothers, Limited, 3, Crosshall-street, Liverpool. [Price 7*s.* 6*d.*]

To say that this book is the story of the Crosville Motor Company from its inception as a small—a very small—privately owned concern to its final absorption in the nationalised road-motor services under the control of the British Transport Commission is the baldest of understatements; it is that, but it is very much more, for it records also an example, which we would like to think is typical, of the kind of individualism which has built up the complex fabric of British industry and which, unfortunately, it is now the fashion to decry in some quarters. There are, it is true, instances in the book of the sort of ruthless competition which ends so often in the weaker going to the wall (though, in the most hard-fought rivalry here recounted, the squeezed-out operator became an active

and most valuable recruit to the Crosville team); but eventually the Crosville Company also yielded to *force majeure*, so that even the critics of private enterprise on the roads may feel that right has triumphed. In any case, they should read the book, if only so that they may realise that here is one authentic case—though there must be others—of a firm for which the proprietors were prepared to make almost any sacrifice of their own time, energy and money in order to keep it going, working literally from dawn to dark, and longer, for less money than they were paying to their 'bus crews; and the 'bus crews responded accordingly, indicating once more how true it is that example is better than precept. Statistics are relegated to an appendix, but it deserves to be studied.

Report on Investigations of the Benzole Technical Committee, 1942-46, on Sludging and Corrosion in Benzole Absorption Plants. Ministry of Fuel and Power. H.M. Stationery Office, York House, Kingsway, London, W.C.2. [Price 6s. 6d. net.]

THE Benzole Technical Committee was set up in October 1942, by the Ministry of Fuel and Power, under the chairmanship of Mr. W. H. Hoffert, of the National Benzole Association, to investigate the sludging of the petroleum oils used for benzole recovery with a view to reducing the loss of crude benzole thus caused; the investigation of corrosion problems was added subsequently to their terms of reference. Some benzole is produced by the distillation of tar, but the main source is the gas produced in coke ovens and gasworks, which is washed with creosote or a petroleum oil. It is the petroleum oil in particular which is liable to sludging, with consequent loss by reduced scrubbing efficiency, poor heat exchange, and the need to shut down the plant for cleaning. While much valuable work was done, as set out in the report, the Committee came to the conclusion that work of a more fundamental character was required as a preliminary to full-scale tests. They recommended, therefore, that the investigations should be continued, and extended to include both coal-tar and petroleum oils; and that pilot plant should be erected, to enable the conditions to be varied under proper control.

CATALOGUES.

Bending Presses.—The Bronx Engineering Company, Limited, Lye, Worcestershire, have issued a leaflet on the range of press brakes which they manufacture for bending sheet and strip metal to special sections longitudinally. The capacities of the machines are between 20 and 150 tons, the lengths of the beams are between 5 and 14 ft., and the number of strokes per minute is 25, 30, or 40, according to size.

Coil-Winding Machines.—Well illustrated details of the Douglas and Macadie coil-winding machines and accessories made by them are contained in a catalogue recently issued by Automatic Coil Winder and Electrical Equipment, Limited, Winder House, Douglas-street, London, S.W.1. Most of the machines dealt with can be demonstrated under actual production conditions at the makers' works.

Swaging Machines.—A brochure issued by Messrs. F. J. Edwards, Limited, 359 and 361, Euston-road, London, N.W.1, contains descriptions of the firm's swaging machines. They are hand or motor driven, depending on the size, and, in addition to plain machines, there are universal swaging, wiring and jennying machines, and a circular guide attachment for jennying, or forming a U on the edge of a disc.

Astronomical Instruments.—Those engineers who can appreciate the structural efficiency, mechanical precision and optical excellence which must be combined in a modern telescope of large aperture if it is to serve its purpose effectively would find much to interest them in the catalogue of large telescopes constructed in recent years by Sir Howard Grubb, Parsons and Company, Walker Gate, Newcastle-on-Tyne, 6, a subsidiary company of Messrs. C. A. Parsons and Company, Limited, Heaton Works, Newcastle-on-Tyne. Both reflecting and refracting telescopes are illustrated, the former type ranging from 18-in. to 74-in. aperture; some of these instruments, it may be mentioned, have been illustrated and described in ENGINEERING. Refractors for visual and photographic work are shown, together with ancillary equipment such as domes, observing platforms, and driving mechanism. Interesting special instruments illustrated are the 16-in. coelostat at Oxford University Observatory (see ENGINEERING, vol. 147, pages 267 and 334, 1939), and the 10-in. photographic zenith tube, to be used for time determinations of the highest accuracy, which was under construction for Greenwich while the catalogue was being printed. Many of the instruments shown, however, were constructed for use in observatories in various parts of the Empire overseas, as well as in foreign countries, so that this highly specialised industry is of more than usual importance at the present time.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.

The date of the advertisement of the acceptance of a Complete Specification is given after the abstract in each case, unless the Patent has been sealed, when the word "Sealed" is appended.

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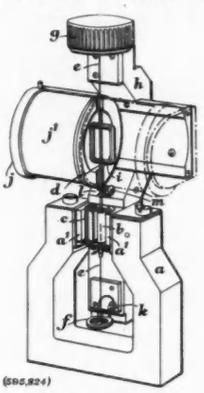
ELECTRICAL APPARATUS.

595,824. Direct-Current Amplifier Galvanometer. N. F. Astbury and C. S. Wright, both of London. (3 *Figs.*) July 14, 1945.—This invention is an instrument which is sensitive to small direct-current signals, for example, of less than 0·1 micro-volt, and converts them to a conventional form for electronic amplification and measurement on a linear scale. The instrument consists of a moving-coil galvanometer movement of known construction having a base formed by a permanent magnet *a* with shaped pole pieces a^1 and a soft-iron core *b* to provide a radial magnetic field for a galvanometer coil *c*. This coil is carried by a slender but rigid stem *d* in a taut conducting torsion-strip suspension *e* between a lower anchorage, consisting of a spiral blade spring *f* and a torsion head *g* mounted on a shaped standard *h* of insulating material attached to the magnet *a*. The stem *d* carries a second coil *i* enclosed by a pair of cylindrical formers *j*, one only of which is shown in full, carrying fixed field coils j^1 wound so as to provide, when supplied with alternating current, an alternating field of uniform density for exciting the coil *i*. Electrical connections are made to



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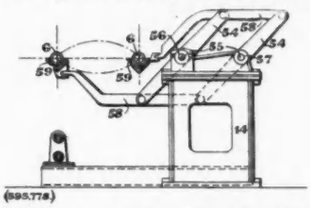
the coils *c* and *i* in the usual way through a terminal *k* at the lower anchorage and through the torsion head *g*, and, in addition, a connection is made to the stem *d* between the two coils by means of a hair-fine wire *l* and terminal *m*, so that the two coils can be connected independently to other apparatus as well as in series. If a direct-current signal is fed to the galvanometer coil *c* the coil will turn in the usual way and move with it the coil *i*. If the field coils j^1 on the formers *j* enclosing the coil *i* are being supplied with alternating current, then an alternating voltage of the same frequency will be induced in the coil *i* and since any movement of the coil *i* will vary its inductive coupling with the field coils j^1 the output of the coil *i* will be amplitude modulated in accordance with the direct-current signal which moves the coil *c*. If the direct-current signal to the galvanometer coil *c* is steady, then the output from the coil *i* can be electronically amplified and rectified by well-known apparatus to give a magnified direct-current signal. If the direct-current signal to the galvanometer coil *c* is not steady, but is a varying signal, then the envelope of the amplitude-modulated output from the coil *i* will correspond with the original direct-current signal and, after amplification, this envelope can be removed from its carrier by a demodulator and be presented as an amplified signal. (*Sealed.*)

MACHINE TOOLS AND MACHINE-SHOP EQUIPMENT.

595,778. Drawing of Metal Tubes. The Wellman Smith Owen Engineering Corporation, Limited, of London, and C. Brooks, of Wolverhampton. (6 *Figs.*) July 2, 1945.—This invention is concerned with draw-bench apparatus for the drawing of tubes. The object of the invention is to facilitate the moving of the plug bars or mandrels successively into line with the die for the drawing operations. The apparatus is installed at suitable points along the mandrel section of a draw bench of known type, and interchanges two plug bars to mandrels by a "parallel motion" device. The device consists of a pair of levers 54 of the double-link type arranged in a vertical plane parallel to each other, the levers having their pivotal axes 55 on the same level. For common operation of the several parallel-motion devices, one lever of each pair is fixed on a horizontal shaft 56 extending along the mandrel section of the draw bench. The other lever of each pair is mounted on an individual pivot 57. Each pair of the levers is connected at the ends by horizontal bars 58, which extend beyond the levers on one side of the mandrel section and are bent upward or downward where necessary to



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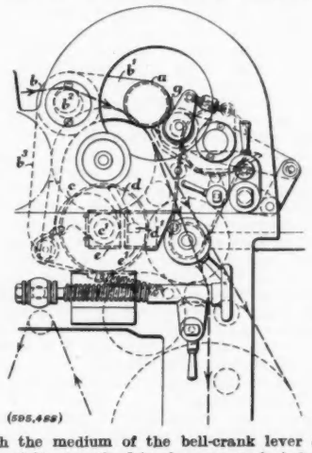
carry at their outer end V-section troughs 59, which support the plug bars or mandrels 6. The parallel-motion devices are power-operated by a double-acting air cylinder on one of the mandrel pedestals 14, preferably the middle one. When the levers 54 are operated, the plug bars or mandrels will move in opposite directions and the path of one will, in section, be an upwardly curved one while the path of the other, correspondingly, will be a downwardly curved one, as indicated by the curved chain-dotted lines. The movement of the mandrels is of lateral nature, but, owing to the curved forms of the paths, the mandrels 6 and their trough supports 59 are able to pass each other to reach their respective limit positions in which the forward ends of the mandrels are opposite the die. (*Accepted December 16, 1947.*)

PRINTING AND ALLIED MACHINERY.

595,488. Rotary Printing Machine. James Halley and Sons, Limited, and A. M. Halley, both of West Bromwich, Stafford. (1 *Fig.*) July 6, 1945.—This improvement in rotary printing machines has for its object to operate the power drive as soon as contact is made between the image roller and the inking roller and to separate the rollers when the power drive is stopped. The image cylinder *a* rotates on the short arm b^1 of a bell-crank lever *b* pivoted at b^2 on the frame of the machine, the long arm b^3 of the bell-crank lever maintaining contact with the periphery of a cam *c* which is set by means of a handle *d*. Operation of the handle results in a horizontal motion of the spring-loaded slide *e*, e^1 associated with the cam shaft c^1, by which the cam shaft is moved horizontally and raises or lowers the image cylinder *a*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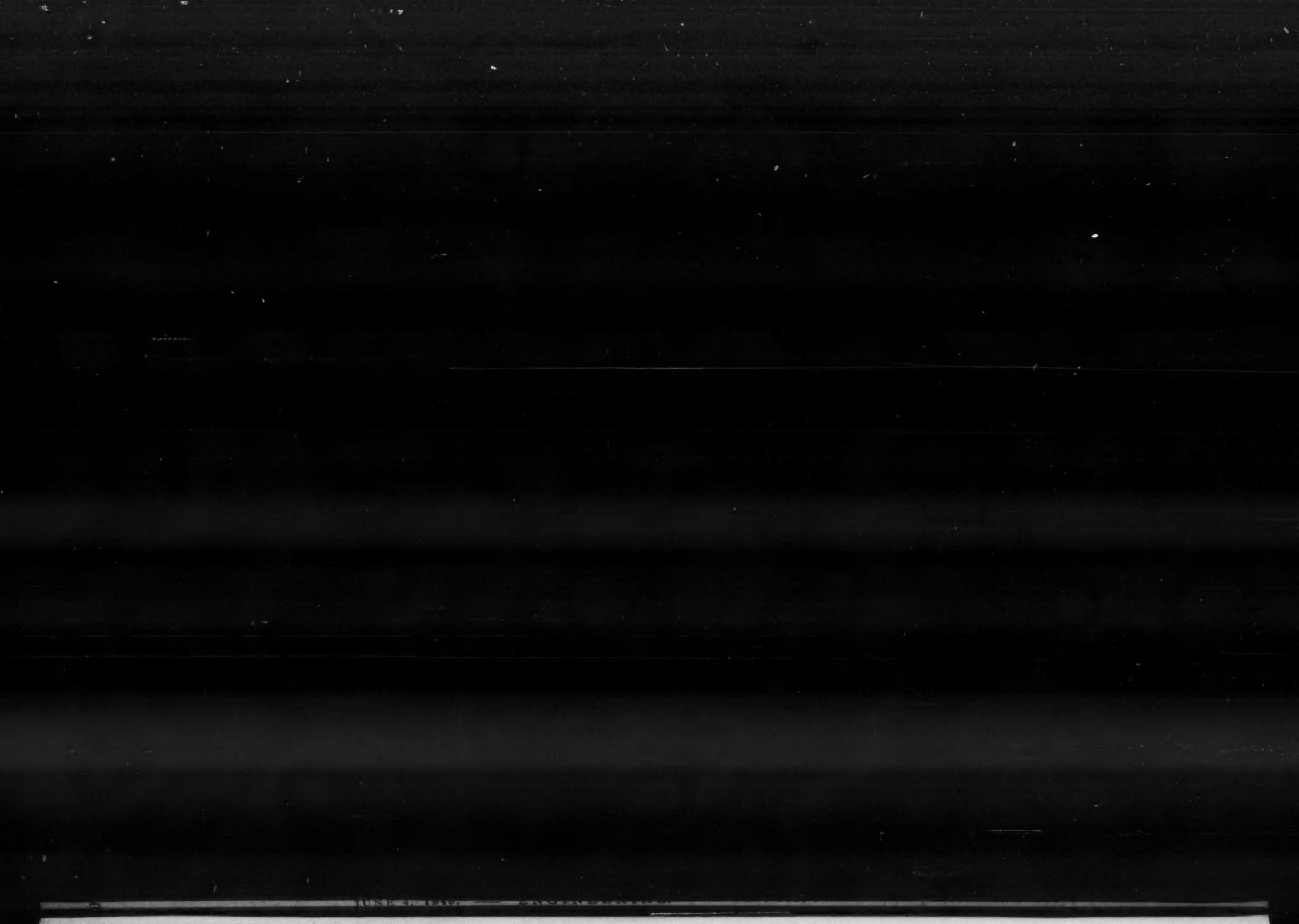
through the medium of the bell-crank lever *b*. The motion of the handle *d* is also communicated through the spindle d^1 to a thrust rod on the opposite side of the machine, which rocks the trigger arm of a switch (not shown) mounted on the side frame of the machine. This switch controls the motor which drives the machine. When the handle *d* is moved to the one position to cause the periphery of the image cylinder *a* to make contact with the inking roller *g*, this motion is transmitted to the spindle d^1 on which the handle *d* is mounted, and thus through the thrust rod and trigger connection to switch on the motor. Opposite motion of the handle *d*, in addition to effecting a removal of the image cylinder *a* from its printing position, also switches off the motor. (*Sealed.*)